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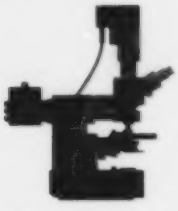
Development of a Reflectogram-based Coke Strength prediction technique applicable to Western Canadian Coking Coals. Final Report

March 1986

Prepared for

CANMET, Energy Research Laboratories.



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Consulting Coal Geologists & Petrographers,
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MAY 30 1986

MICROMEDIA

Work on this contract was conducted under the auspices of the Canada Centre for Mineral and Energy Technology, Energy, Mines and Resources, Canada.

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March 13, 1986.

Ref:07SQ.23440-4-9280

Dr. J. T. Price,
Research Scientist,
Energy Research Laboratories,
CANMET,
555 Booth Street,
Ottawa,
Ontario,
K1A 0G1.

Dear Dr. Price:

Re: Development of a Reflectogram-Based Coke-Strength Prediction Technique Applicable to Western Canadian Coking Coals. (UP-P-187)

We are pleased to provide you with the final report of the above described contract.

We trust that these data meet with your approval, and we thank you for the contract that allowed us to finance the study.

Yours very truly,
David E. Pearson & Associates Ltd.,

David E. Pearson Ph.D., P.Eng.

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Letter of Transmittal

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Summary

The work described in this report is concerned with the development of techniques for predicting the cold strength of metallurgical coke directly from reflectograms of western Canadian coking coals, produced by either automated or manually-controlled microscope-photometer systems.

At present, the prediction of metallurgical coke strength employs a 1960-vintage method, that does not always give satisfactory results (especially with western Canadian coals), that can only be used with manual microscope photometer systems, and which is slow, taking from 3 to 6 hours per sample.

The work described here offers a unique solution to the prediction of coke strength. Using multiple linear regression analysis of reflectance data, it is shown how coke strength can be predicted to a level of assurance that is superior to the previous technique.

The level of assurance governs the number of partitions into which reflectance data are classified, but by using a universally-acceptable class size of 0.10% random reflectance (a V-step), semi-automated reflectograms can be used to predict coke strengths to ±2.4 stability units at the 68% confidence level (twice this at the 95% level). No discrimination is made between coal macerals in these reflectograms.

In a completely automated system, in which there is **no human intervention of any kind** an automated reflectogram partitioned into V-step classes can predict coke strength to ±3 stability units.

Both of these methods are superior to any photometer-based method available today.

Now that the feasibility of the method has been demonstrated, modifications to the hardware of the systems should make it possible to generate very accurate coke strength predictions on automated equipment from 100,000-count analyses in about 30 minutes. There is an exciting commercial opportunity available in the marketing of such a Canadian-designed and built system.

The results of this study should prove of considerable benefit to the coal export industry of western Canada and to the Canadian steel industry.

1.0. Introduction

COKE STRENGTH PREDICTION

Prediction of coke strength, based on measurements of vitrinite reflectance and data from maceral analysis of coal, is of fundamental importance to coal-exporting companies of western Canada and steel producers of central Canada, and is of interest to a number of Federal government agencies. Most of the steel companies and government agencies have automated microscope-photometer systems for the rapid acquisition of reflectance data on coals, but to date, despite the large amounts of data that these systems generate, they have not been able to predict coke strength.

At present, coke strength prediction can be performed only by coal petrographers using manual microscope photometer systems, and even then, they often experience difficulty in accurately predicting coke strength, especially of western Canadian coking coals. This is caused by a problem inherent in the conventional method of coke strength prediction, and by the fact that considerable skill is required in the correct identification of macerals.

CONVENTIONAL CALCULATION OF COKE STRENGTH

According to Mackowsky (1977), the principal coke-strength prediction techniques employed in Soviet, North American, Japanese, British, and Italian laboratories are based on the method of Schapiro & Gray (1960), in which a mathematical algorithm derives two parameters; the Strength Index, and the Composition Balance Index. Using standard tables, these two parameters predict the coke strength, which is then known as the Stability Index.

Schapiro & Gray's algorithm requires two independent sets of data that are acquired in separate analyses, which are:

Analysis 1. Distribution of maximum vitrinite reflectance data, categorized by V-type (vitrinite reflectance x 10).

Analysis 2. The percentage of reactive macerals (exinite, vitrinite, and reactive semifusinite), corrected for the mineral matter content of the coal.

These data are routinely collected in manually-operated microscope-photometer systems specifically for conventional computation of coke strength.

A problem with the Schapiro & Gray technique, however, is that in Analysis 2, it requires the correct identification of the maceral semifusinite and then makes an assumption that

$$R=kT$$

where: R=Reactive Semifusinite
k=constant (0.33)
T=total semifusinite

Among coals that have small total semifusinite contents, a departure of the value of k from the assumed value does not make a significant difference to the predicted coke strength. However, where the total semifusinite population is large, say 50%, then if k differs from the assumed value, the effect on the predicted coke strength is profound. For these reasons, among coals from western Canada, Australia, and South Africa, which tend to be enriched in semifusinite, the Schapiro & Gray method of coke strength prediction has frequently proved to be unsatisfactory.

According to Kojima & Sakurai (1980), at Nippon Steel Corporation's laboratories in Japan, it takes 2 hours to collect 100 vitrinite readings in Analysis 1, and 1/2 hour to collect 500 readings in Analysis 2. For comparison, in our laboratory we collect 100 reading in the first analysis, and 1000 readings in the second analysis, at similar or faster acquisition speeds. The total time involved in the determination of the coke strength of one sample varies from a minimum of 3 hours to a more realistic 6-7 hours, with accuracy that depends upon the relatively small number of measurements.

AUTOMATED MICROSCOPE-PHOTOMETER SYSTEMS

Throughout the world coal petrographic laboratories are turning to automated microscope-photometer systems because they are computer-based, and therefore offer an unattended and rapid means of increasing accuracy of analysis with their ability to take very many more measurements of the same sample. These numerous values are organized in the form of reflectograms (reflectance histograms), which are generated by the random reflectance of all macerals encountered in traverses across a coal pellett on a fixed, non-rotating microscope stage. The analysis results from automated systems are different from those described above and consist of large numbers of reflectance readings on unidentified macerals.

The two principal microscope manufacturers, Leitz & Zeiss, both offer automated systems, and examples of both are operational in Canada. The locations of such systems are:-

<u>Zeiss Zonax System</u>

Geological Survey of Canada, Dartmouth, Nova Scotia.
Geological Survey of Canada, Calgary, Alberta.

<u>Leitz Tas & Dads Systems</u>

University of British Columbia, Vancouver.

Unfortunately, there has not been a concommitant development of microscopy techniques to allow optimum use of these automated systems. For example, at the beginning of the contract, we knew of no automated system in the world that could perform the following:

1. Separation of reflectance classes into reactive- and inert-maceral categories.

2. Separation of random vitrinite reflectances from values of other macerals.

3. Prediction of coke strength by the conventional approach.

That situation has changed somewhat with the announcement by Nippon Kokan NKK in Japan, of an automated image-analysis system that uses a video camera to determine maceral distribution and a photometer to determine vitrinite reflectance. However, with a price tag of $US250,000, there is obviously room for the Canadian development of cheaper, smaller, automated systems. That is the aim of this research.

2.0. Samples

Sixty one coal samples were provided by four coal companies for use in this study. The samples are in pellet form and are splits of bulk samples that have been previously carbonized in the CANMET Laboratories in Ottawa. These pellets have been previously characterized petrographically in our laboratory.

The provenance of these samples is listed below:

Quintette Coal Limited, Tumbler Ridge, 28 samples.

Crows Nest Resources Ltd., Sparwood, 19 samples.

Fording Coal Limited, Elkford, 9 samples.

Smoky River Coal Ltd., Grande Cache, 4 samples.

Provenance Unknown, 1 sample.

The samples are identified by CANMET library numbers as follows:-

2153	1941	1070	1371	416	1354	2231
2042	1864	1026	1372	417	1396	
2009	1829	1025	1373	993	1471	
2007	1830	1073	1374	1068	1486	
1828	1769	1375	1500	1069	1487	
1680	1772	1081	1501	2150	1515	
2233	1827	278	1504	2151	1565	
2006	284	1005	1505	2152	1446	
2012	267	1072	1604	1349	2266	
2008	1082	1080	1605	1353	2234	

As a test, a typical western Canadian coal sample that was used in an international round-robin with European coal petrographers in 1985, was chosen. Dr. Boris Alpern, President of the International Committee of Coal Petrology (I.C.C.P.), was interested in an inter-laboratory study of this inertinite-rich coal, which was provided by CANMET. This sample is identified as Alpern's Canadian sample.

3.0.
Method of Study

This research is concerned with the development of a coke strength prediction technique that is based wholly on reflectograms and which can be used with semi-automated (manual) or automated microscope-photometer systems. Each of these systems is described below and example reflectograms, using the same sample in a semi-automated and an automated system, are shown as Figures 1 & 2.

SEMI-AUTOMATED SYSTEM

The semi-automated system used in this study comprises a Leitz MPV Compact photometer attached to a Leitz Orthoplan microscope. A Swift Automatic Point Counter (Model E), with mechanical stage, is used to obtain information on maceral counts. An internal interface board connects the Swift point-counter to a Hewlett-Packard 85 microcomputer BCD interface. Software is then used to acquire reflectance data simultaneously when keys are depressed on the point counter. The HP 85 also captures the data for later processing. This system has been in use in our laboratory since 1983.

AUTOMATED SYSTEM

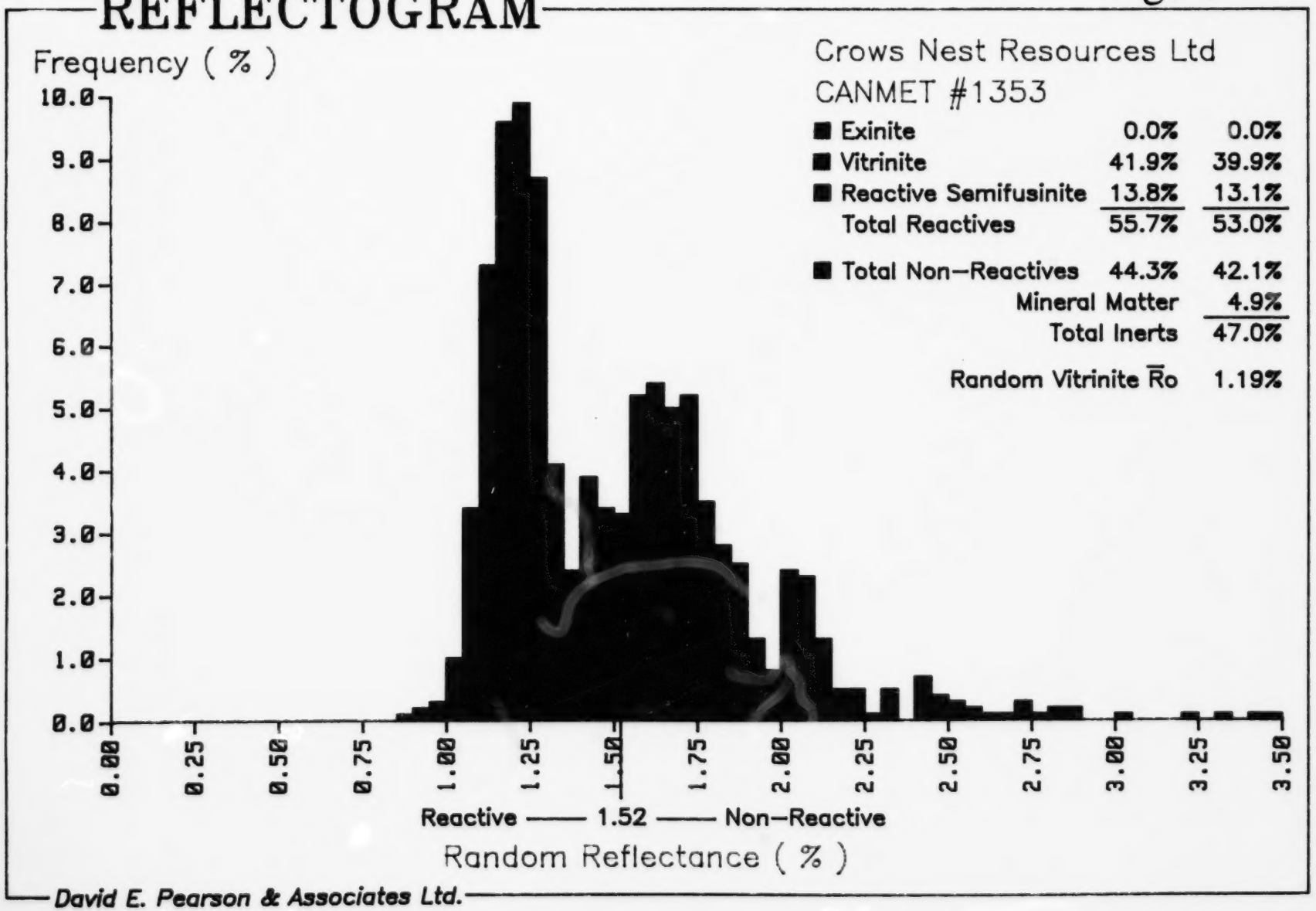
The automated system used in this study is a Leitz MPV Compact photometer on a Leitz Orthoplan microscope, to which is attached a Meerhauser EK32 scanning-stage. The stepping motors of the stage and sampling of the photometer are contolled over a BCD interface by software running on a Hewlett Packard 9816 microcomputer.

With the semi-automated system, there is manual intervention by an operator who identifies the type of coal maceral being examined. Simultaneously with this identification a reflectance measurement is made and this process is repeated to the end of the analysis. Focussing and data recognition, therefore, are manual and a microcomputer is used only to capture the data, move the stage to the next sample point and manipulate and present data. Problems inherent to the method are discussed below.

Grain Boundaries

In the automated system, all functions are controlled by the computer. Consequently, there is no distinction between macerals, nor between low-reflecting macerals and grain boundary readings which incorporate low light-values reflected from the binding material. To overcome this problem, initially the checking-system for grain boundary recognition described by Kojima & Sakurai (1980) was used. In this method a reading is made, the stage is moved 10μm and another reading taken. If the two readings differ by more than 20% both are discarded and the stage is moved 100μm to the next station. If the second of a pair of readings is within ±20% of the first, both values are summed and their mean value

Figure 1


REFLECTOGRAM
Frequency (%)
Crows Nest Resources Ltd
CANMET #1353
Exinite 0.0% 0.0%
Vitrinite 41.9% 39.9%
Reactive Semifusinite 13.8% 13.1%
Total Reactives 55.7% 53.0%
Total Non–Reactives 44.3% 42.1%
Mineral Matter 4.9%
Total Inerts 47.0%
Random Vitrinite R̄o 1.19%
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.00 0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50
Reactive —— 1.52 —— Non–Reactive
Random Reflectance (%)
David E. Pearson & Associates Ltd.

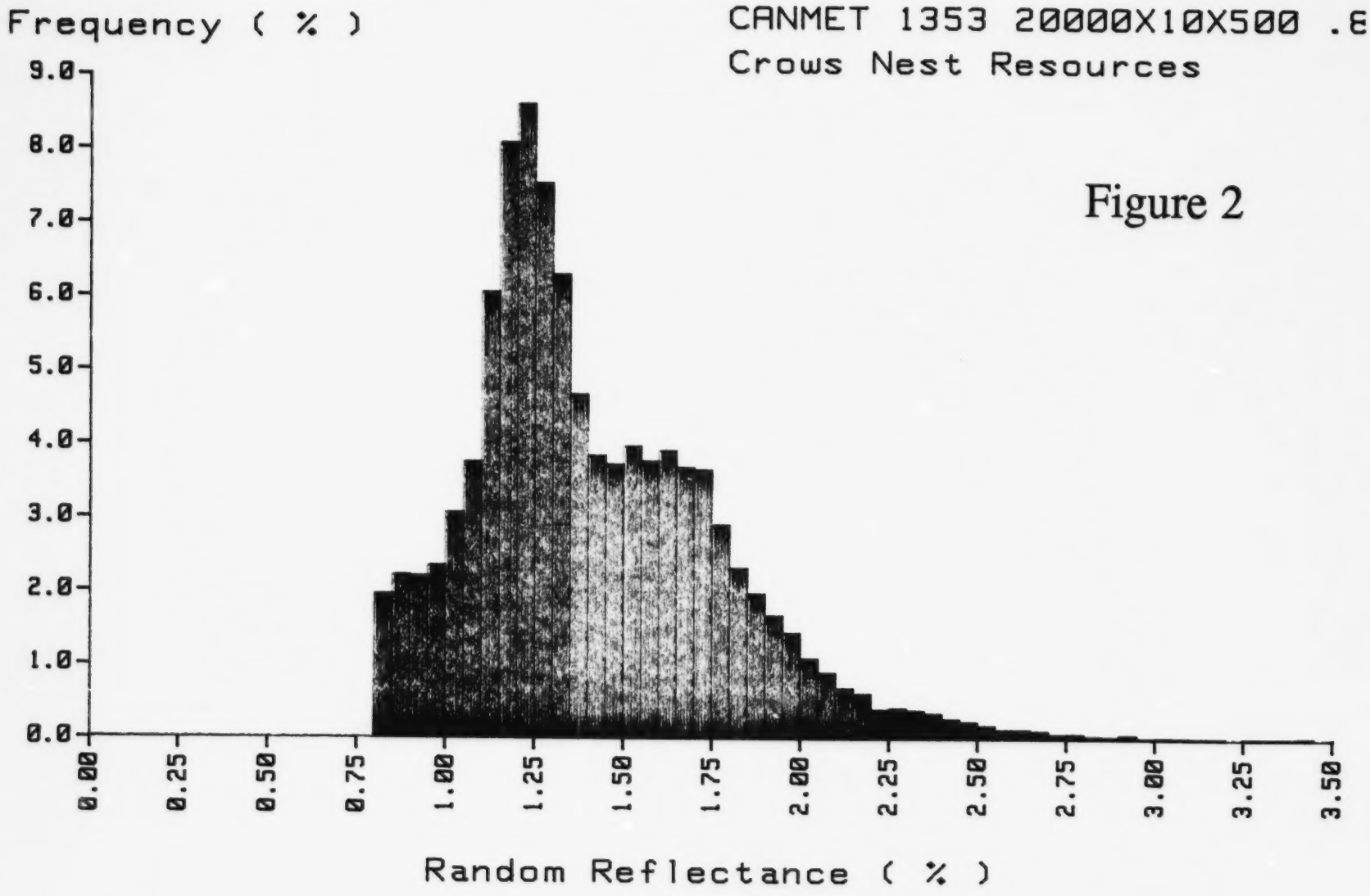

Frequency (%)
CANMET 1353 20000X10X500 .E
Crows Nest Resources
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
3.25
3.50
Random Reflectance (%)

Figure 2

is retained by the computer. Using this approach, large numbers of readings were rejected and the problem of grain boundaries and their recognition was not really resolved. Instead, another approach was tested and used. Using a measuring diameter in the photometer of 10µm, the stage is moved incrementally 10µm in the X-direction to the next sampling station, and, in effect, reflectance is being measured continuously along a traverse line. In this way, although many readings will be made on an individual grain, the ratio of edges to whole coal is reduced to the lowest possible number. If sufficient individual grains are measured, sample biasing will not be evident.

Low Reflecting Material

Semi-automated reflectograms contain reflectance measurements of each maceral that has been observed by the operator. These reflectograms are consistent in their shapes; the vitrinite reflectance distribution is distinctly Gaussian-looking, as is that of Inertinites. By contrast, automated reflectograms, which do not discriminate between macerals, always contain considerable volumes (0-10%) of readings to the left of the vitrinite peak. These readings are mixtures of grain-margin materials and binder together with liptinite macerals. The liptinite maceral content of these samples is generally less than 0.5%, with only four samples possessing greater than 2%.

To reduce the percentage of this non-coal material, a cut-off for the reflectance was imposed at 0.8%. Since the mean reflectance for the 61 sample suite is 1.30%, with only 4 samples with means less than 1.10%, the 0.8% reflectance cut-off is equivalent to a minimum of three standard deviations (≈0.08%) from the mean reflectance value.

STATISTICAL ANALYSIS

The reflectance measurements obtained from the semi-automated and automated microscope-photometer systems formed the database for the study. These data were tranferred by 1200-baud modem to the MCS 68000 computer of Autonetics Research Associates Ltd., Sooke, British Columbia, who performed the statistical analyses. The results of these analyses were relayed back to our laboratory in a similar fashion.

Simple statistical parameters such as the mean, standard deviation, skewness and size of population were determined for various maceral populations (as discussed in the Results). The non-parametric Kolmogorov-Smirnov test was used to test populations for their approach to Gaussian distributions, whereas the F-test , which is parametric and assumes a normal distribution, was not. Multiple linear regression techniques were applied to reflectogram data from both the semi-automated and automated systems.

4.0. Results from Semi-Automated Reflectograms

The format adopted here to descibe the results follows in a general way that of the Work Statement of October 1, 1984, which is contained in the Appendix. The development of the reflectogram-based coke strength prediction technique follows from an earlier CANMET contract that demonstrated the method of determining Total Inert content of a coal using a Reflectance Cutoff technique. The first section of these results refer to the reflectograms generated in that study.

REFINEMENT OF SEMI-AUTOMATED TECHNIQUE

This section seeks to determine the best method for determining the Reactive-Cutoff by linear regression of the cutoff with:-

(1) Mean Random Ro.
(2) Standard Deviations of Ro.
(3) Other parameters.

Figure 3, shows the correlation of Random vitrinite reflectance versus the Reactive Cutoff for the suite of 54 samples from the earlier study. The equation of the line is:-

$$\text{Reflectance Cutoff} = 1.109(\text{Random Ro}) + 0.2185.$$
$$R^2 = 0.898$$

Figure 4 shows a plot of Reactive Cutoff versus standard deviation of Random Ro for the suite of coals. The equation of the line is:

$$\text{Reflectance Cutoff} = 6.367(\text{St. Dev.}) + 0.8449$$
$$R^2 = 0.618$$

Figure 5 shows a plot of (Reactive Cutoff - Ro Random) versus standard deviation of the Vitrinite. The equation of the line is:

$$\text{Cutoff-Random Ro} = 1.5735(\text{St. Dev.}) + 0.1869$$
$$R^2 = 0.332$$

Now that these additional analyses have been made, it is apparent that the superior method of computing the Reactive Cutoff is by using the mean maximum reflectance of vitrinite in the following equation, shown in Figure 6.

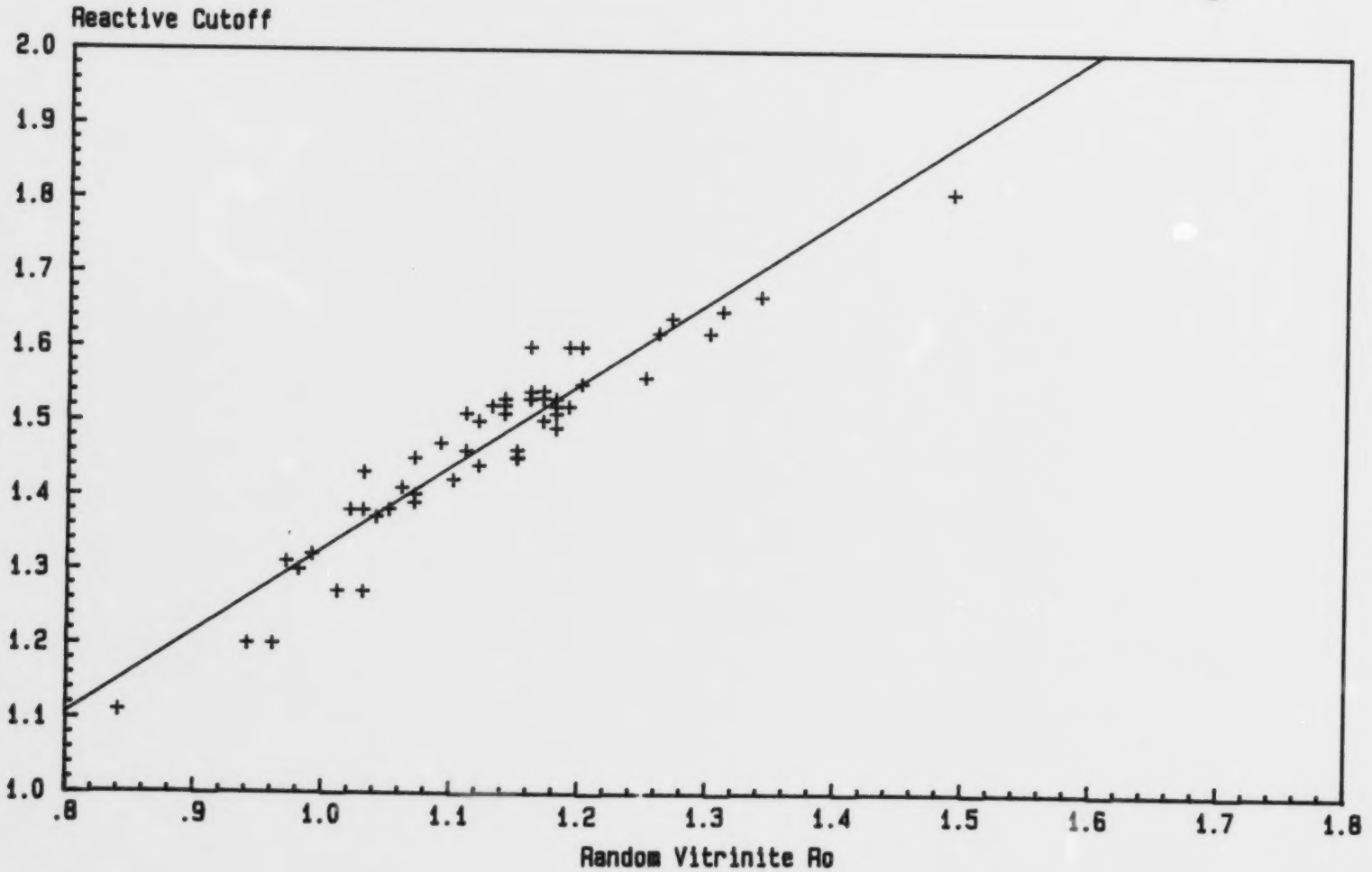
$$\text{Reflectance Cutoff} = 1.000(\text{Romax}) + 0.2206$$
$$R^2 = 0.957$$

Correlation Random Vs. Cutoff

54 Sample Suite

Linear
Regression

Figure 3



Correlation Cutoff Vs. Std. Dev.

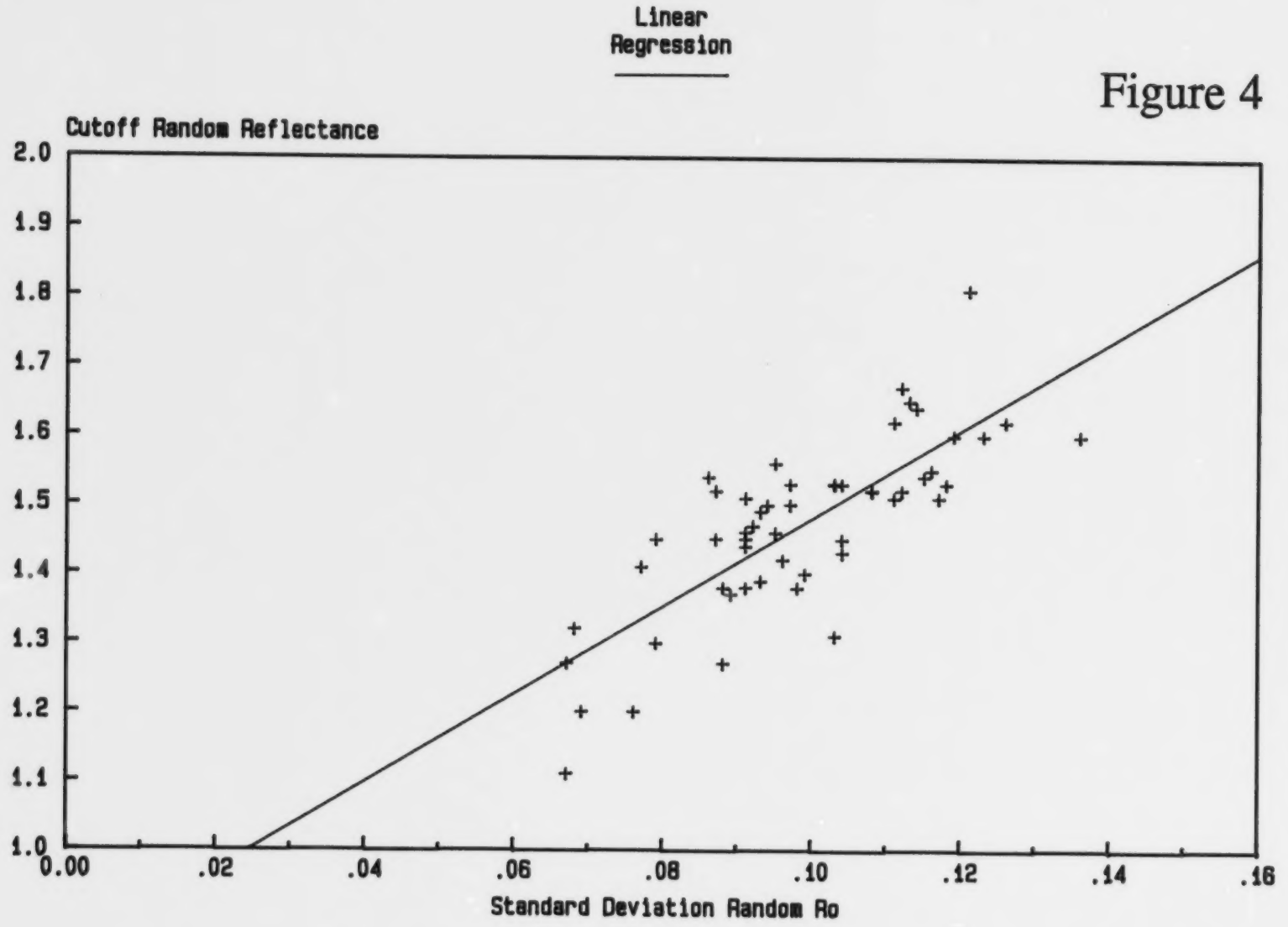
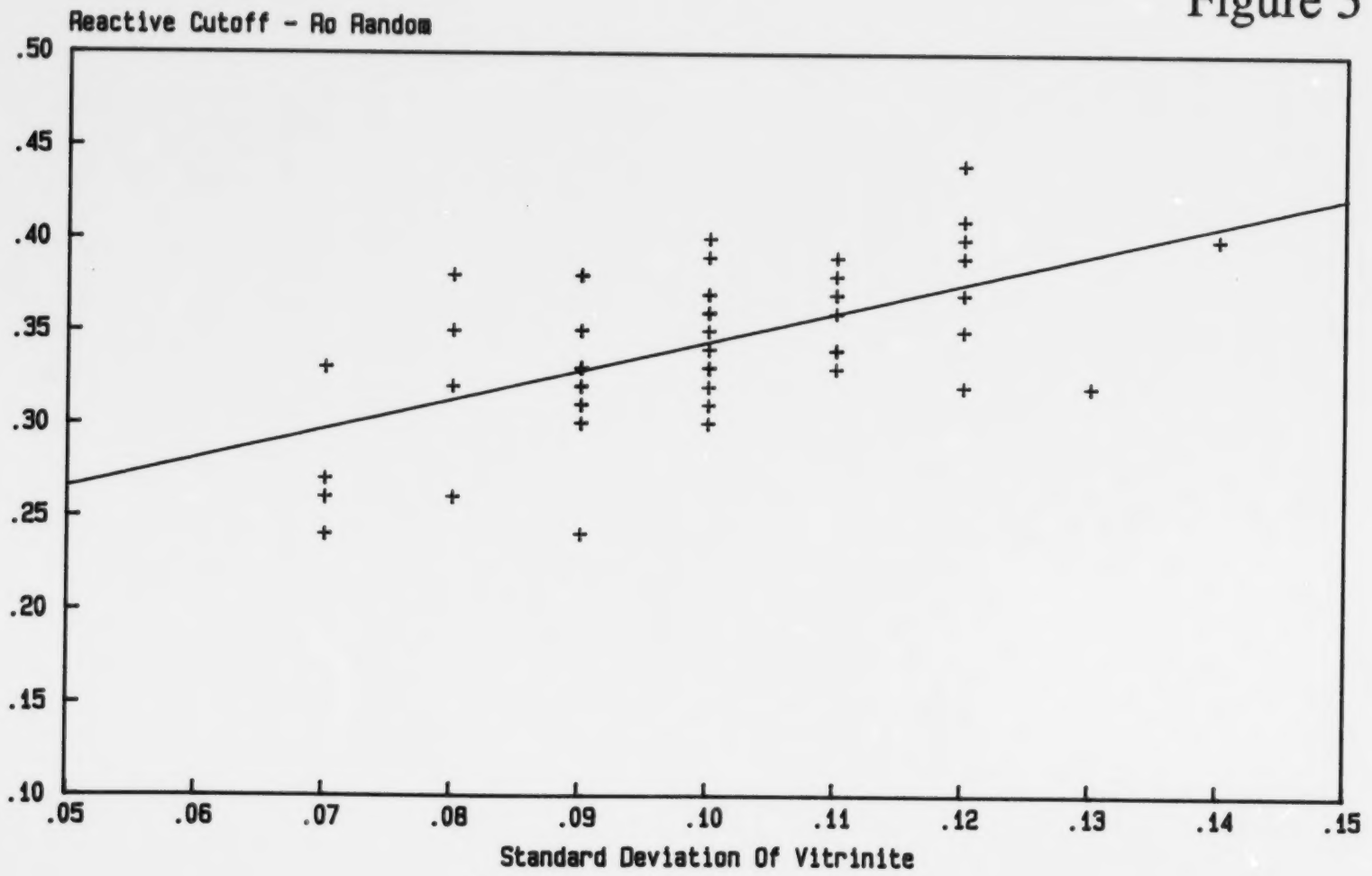


Figure 4

(Cutoff-Ro Random) Vs. Std. Dev.

Correlation Of Reactive Cutoff

Figure 5



Correlation Romax Vs. Cutoff

Seventy Western Canadian Coals

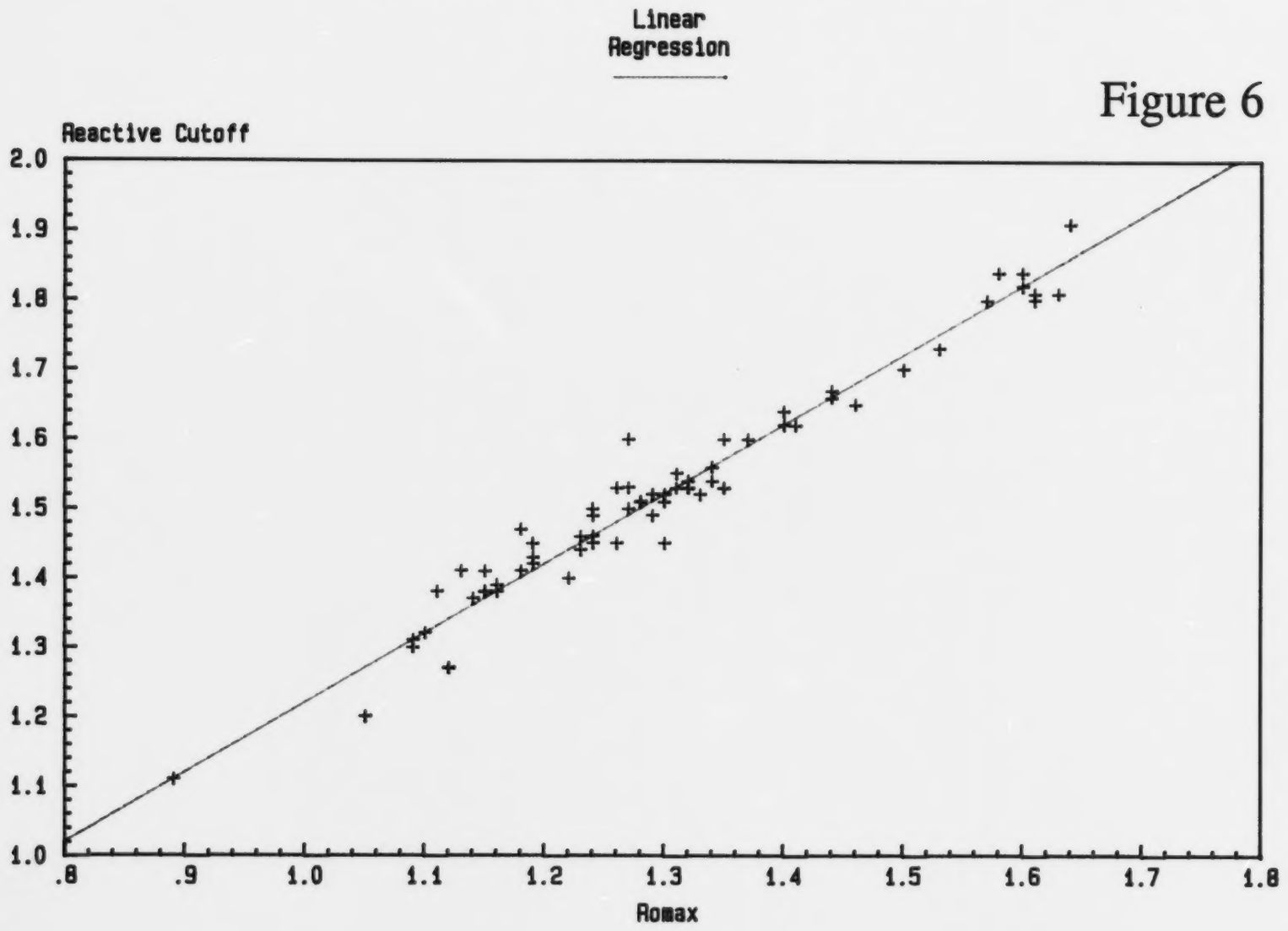


Figure 6

PROBABILITY DISTRIBUTIONS

Plotting cumulative distributions of vitrinite and inertinite populations on arithmetic probability paper allows inferences to be drawn about the nature of the distribution of the populations.

Figure 7 is a typical example of a probability plot. In this diagram, the straight red and blue lines represent, respectively, the perfectly Gaussian distributions of the vitrinite and inertinite populations that have the mean and the standard deviations shown at the lower right of the page. The second red and blue lines represent the actual cumulative probability distributions of the vitrinite and the inertinite populations.

The observed small deviation of the vitrinite population from the theoretical straight-line distribution shows that, within the limits of experimental error, the random reflectance of vitrinite can be regarded as a normal or Gaussian population. This pattern prevails for all samples. However, the observed departure of the inertinite population from the theoretical Gaussian distribution is too large to be fortuitous. In all cases examined, there are too-few low-reflecting inertinites (<1.5%), and the population always falls short of the theoretical distribution. Similarly, there are always too-few highly-reflecting inertinites (>2.0%), and the population again falls short of the theoretical straight-line gaussian distribution. Close examination of Figure 7 shows, however, that the inertinite probability distribution consists of two straight arms which meet in the vicinity of the mean for the population. From these data it could be inferred that the inertinite population is actually composed of two sub-populations, both of which are normally distributed, and which appear approximately equal in size.

It is concluded from probability distributions of the sample suite that the vitrinite population is normally distributed about the mean, whereas the inertinite population, (as currently defined) is not normally distributed.

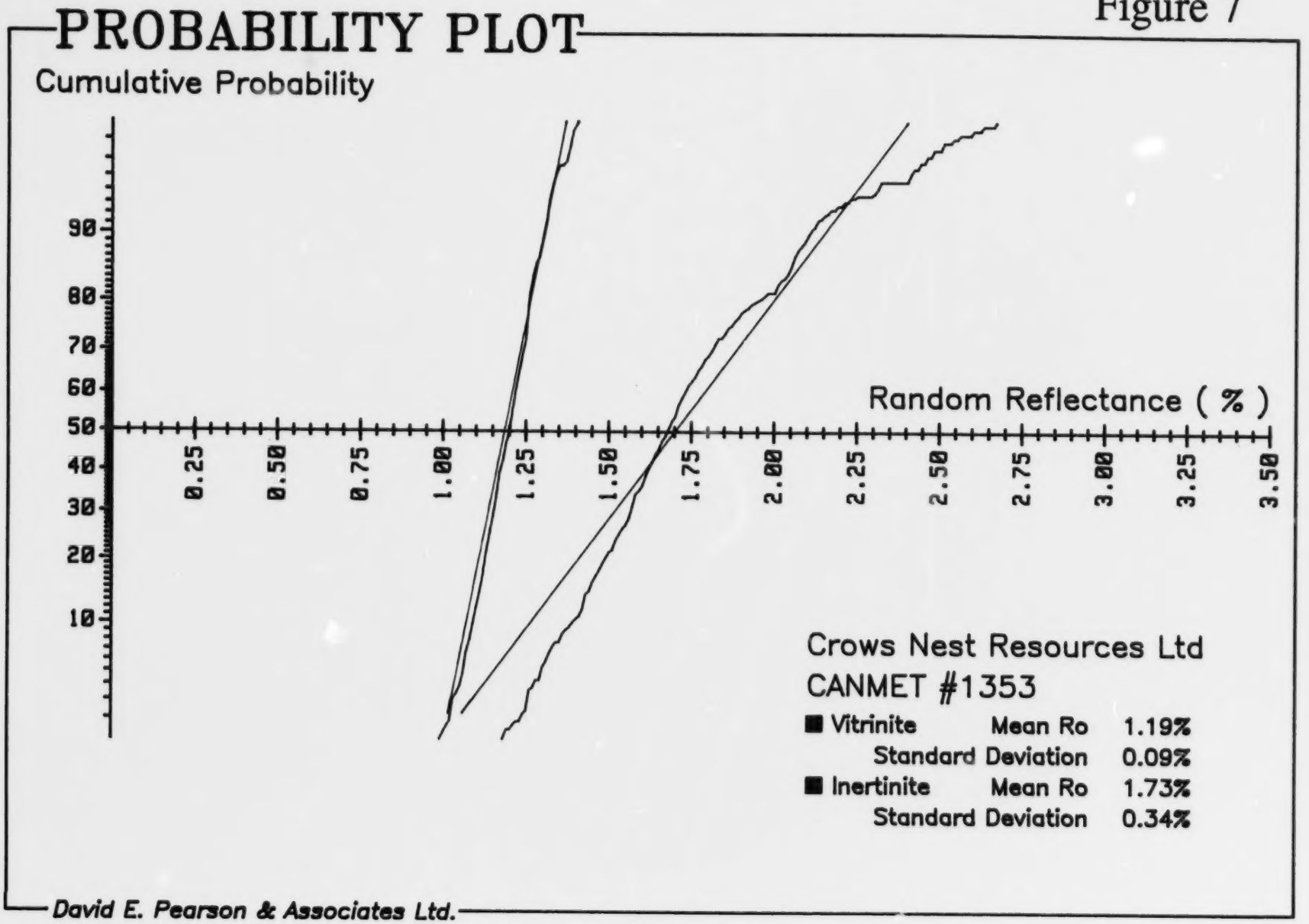
VERIFICATION OF NORMAL DISTRIBUTIONS

This test evaluates the approach to normality of a measured population by comparison with a similar theoretical gaussian distribution.

The Kolmogorov-Smirnov test (Kreyszig 1970, Hoel 1971, Sachs 1982), is a non-parametric procedure which tests the hypothesis that F(x) is the distribution function of the population from which the sample $X_1, X_2, \ldots\ldots X_n$ was taken.

First the mean, variance and number of observations of the data are evaluated thus establishing the Gaussian parameters. Then, using a Remes approximation (Hastings, 1955) for the cumulative values arising from this theoretical distribution, the maximum deviation between theoretical and assumed ordinates is evaluated.The result is compared with tabulated values (*loc.cit.*) to establish the validity, or otherwise, of the hypothesis.The most stringent test available in the tables is that at 20%.

Figure 7


PROBABILITY PLOT
Cumulative Probability
90
80
70
60
50
40
30
20
10
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
3.25
3.50
Random Reflectance (%)
Crows Nest Resources Ltd
CANMET #1353
Vitrinite Mean Ro 1.19%
Standard Deviation 0.09%
Inertinite Mean Ro 1.73%
Standard Deviation 0.34%
David E. Pearson & Associates Ltd.

As with all non-parametric tests this one is much less precise than tests based on normal distributions and the deviations from normality which we observe are easily accounted for by the limited numbers of observations.

Tables 1-4 contain the results of the test applied to vitrinite distributions, reactive semifusinite distributions, all Inertinites and all non-reactive Inertinites. The data comprise the number of readings N, the mean, the variation, the skewness, the deviation limit of the Kolmogorov-Smirnov at the 20% level, the determined deviation and the acceptable limits of the test.

The Kolmogorov-Smirnov test results show that all vitrinite distributions are well within the bounds for normality specified in the test (that is, the K-S values are less than the acceptable deviation [LIM]) and the distributions are regarded as normal. For semifusinite distributions, the test for normality is satisfied in 26 cases and a further 16 cases are acceptable at a slightly reduced level, for a total of 42 of the 58 sample sets. However, when the reactive semifusinite population is combined with the non-reactive inertinites, the semifusinite results deteriorate to 2 fully satisfied cases and 7 marginal ones. For the inertinites as a group, none of the samples approach normality.

MULTIPLE CORRELATION CALCULATIONS

This section establishes parameters for use in algorithms to predict Romax and coke strength.

Multiple correlation calculations were made between Romax and the parameters N, mean, standard deviation and skewness for the two maceral groups, vitrinite and inertinite (File:Bigauss) and also for the three types, vitrinite, reactive semifusinite, and non-reactive inertinites (File:Trigauss). These data are contained in Tables 5 & 6.

In the case of vitrinite and inertinite, the maximum deviation between predicted and observed Romax values is -0.09 for sample #2, where the experimentally derived value is 1.27 and the predicted value from the 6 correlation coefficients is 1.36.

For the nine parameter prediction formula derived from Vitrinite, Reactive Semifusinite, and non-reactive inertinite data, the maximum error is -0.02, again for sample #2. In this instance, the predicted Romax is 1.29 and all other predicted values are either ±0.01 or 0.00.

It is concluded that, based on nine statistical parameters derived from semi-automated reflectograms, the Romax of a coal falling within the same population can be predicted to within ±0.02.

Multiple correlation calculations have also been made between coke strength, sample size N, mean, variance, and skewness for the two macerals vitrinite and inertinite (Table 7, File:Rctums), and also for vitrinite, reactive semifusinite and non-reactive inertinite (Table 8,File:Rctan). For the vitrinite and inertinite combination, the greatest difference between predicted and observed coke strength is 11.25.

The sum of the squared errors is 916.168, or an average ±3.97 stability units for each coal in the 58 sample set. For the vitrinite, reactive semifusinite and non-reactive inertinite combination, the greatest difference between measured and predicted coke strength is -8.28. The sum of the squares of the differences is 570.192, or an average of ±3.14 stability units for each coal in the 58 sample set.

It is concluded that, on the basis of the nine statistical parameters, the coke strength of a coal falling in the same population as the sample suite can be predicted to ±3.14 stability units. This error is greater than that achieved by currently used methods.

This section describes multiple correlation calculations on the complete reflectogram, without identifying the maceral types.

In an attempt to investigate the importance of human intervention at the microscope, during maceral identification, and also to determine whether or not an analysis of shape would prove a more sensitive method of prediction, multiple linear regression of whole reflectograms was undertaken. In this approach, no distinction was made between the maceral types; only the reflectance data in each reflectance class was considered.

The data were gathered in the form of V-types, or units of 0.10 reflectance, from 0.5 to 2.5 %Ro Random, and from 0.5 to 3.0 %Ro random. For the 21 point sample set (Table 9, File:RGAMS21), the greatest difference between predicted and actual coke strength is -5.03, and the sum of the squares of the differences is 330.667. This is an average of ±2.39 stability units for the 58 sample suite. Using the 25 point sample set (Table 10, File:RGAMS25), the largest difference between the predicted and actual coke strength is -4.58. The sum of the squares of the differences has dropped to 264.623, or an average of ±2.14 for each coal in the 58 set suite.

As a further test of this approach, the sample from the 1985 international round robin between European-ICCP coal petrographers and Canadian coal petrographers was used in the equation. A coke strength of 51.7 was obtained, compared with a value of 50.0 predicted by the reflectogram approach, and an actual coke strength of 49.9.

5.0. Results from Automated Reflectograms

Sixty-one automated reflectograms were produced in this study which are on file with CANMET. An example of a typical automated reflectogram is presented as text figure 2. Each reflectogram consists of 20000 reflectance values ranging from 0.8 to 3.5%Ro random, on a variety of macerals that were not identified.

COKE STRENGTH

In the first series of analyses, 57 of the 61 reflectograms were partitioned into 20 cells, 30 cells or 50 cells, and the number of readings in each cell was treated as an independent variable in a multiple linear regression against the coke strength of the sample, which was the dependent variable. Coke strength predictions on samples #1446, #2266, #2234 & #2231 are from a population (low volatile coals), different from the 57 for which the coefficients were determined.

The coefficients for the 20-cell analysis, and the predicted and observed coke strengths are shown as File:Coke20, in the appendix. The sum of the squares of the differences is 940.007 and the root mean square (RMS) error is 3.925. The largest single difference is 22.05 for sample #2266, outside of the coefficient set, and +6.39 from those within it.

The coefficients for the 30-cell analysis, and the predicted and observed coke strengths are shown as File:Coke30, in the appendix. The sum of the squares of the differences is 1177.374, and the RMS error is 4.39. The greatest difference is 29.36, again for sample #2266, outside of the coefficient set, and for the coals within the coefficient population the largest difference is -6.10.

The coefficients for the 50-cell analysis and the predicted and observed coke strengths are shown in File:Coke50, in the appendix. The sum of the squares of the differences is 519.268 and the RMS error is 2.91. The largest single difference is -2.59 but from the coals outside of the population for which the coefficients have been determined, the difference is 15.92.

Coefficients were also derived for the full suite of 61 samples when the reflectograms were partitioned into 50 cells. These data are shown in the appendix as File:61coke50. Coke strength predictions for the four errant samples, #1446, #2266, #2234 & #2231, are now sensible; the sum of the squares of the differences are reduced to 6.119 and the RMS error is 1.00. The greatest difference between determined and predicted coke strength is -2.49.

Since the RMS error is greatest for the smallest number of partitions (2) of the reflectogram, and becomes zero when the number of cells equals the number of samples (61), there must be an optimum number of cells for a reflectogram relative to an acceptable level of RMS error. To investigate this phenomenon, the reflectograms of the 61 coal samples were partitioned into smaller and more numerous classes of 2, 3, 4, 5.....to 40

partitions. The coefficients and RMS errors were calculated in each case.The root mean square (RMS) error for the different numbers of cells in the histograms are shown in the appendix as File:61cokerms and graphically as text Figure 8.

This diagram shows that for coke strength predictions of ±3 stability units, automated reflectograms of coals from within the same population of coals, as has been examined, should be partitioned into 17 or more classes. In this case, each class would be equal to 0.1 %Ro Random, or one V-type. For stability predictions of ±2 stability units, 50 classes are required. The logarithmic curve shown in the diagram has a correlation coefficient of 0.965 and its slope is RMS = 6.135E+000+-0.111E+001log(X).

ROMAX

In the second series of analyses, 57 of the 61 reflectograms were partitioned into 20 cells, 30 cells or 50 cells, and the contents of each cell were treated as an independent variable in a multiple linear regression against the mean maximum reflectance of the vitrinite (Romax) of the sample, which was the dependent variable. In reviewing the results of these analyses, samples #1446, #2266, #2234 & #2231, are outside of the population from which the coefficients were derived, and using them to predict of their vitrinite reflectance may not be satisfactory.

The coefficients for the 20-cell analysis, and the predicted and observed Romax are shown as File:Romax20, in the appendix. The sum of the squares of the differences is 0.1603 and the root mean square (RMS) error is 0.0512. The largest single difference is 0.23 for sample #2266 but only 0.13 for a coal from the coefficient set.

The coefficients for the 30-cell analysis and the predicted and observed Romax values are shown as File:Romax30, in the appendix. The sum of the squares of the differences is 0.0914 and the RMS error is 0.0387. The greatest difference is 0.17 for sample #2266 but only 0.06 for samples from the coefficient set.

The coefficients for the 50-cell analysis and the predicted and observed Romax values are shown in File:Romax50, in the appendix. The sum of the squares of the differences is 0.9123 and the RMS error is 0.12223. The largest single difference is 0.8 for sample #2266 and 0.03 for the coefficient set samples.

The optimum number of reflectogram cells had to be determined to provide an acceptable RMS error level (as in the previous case regarding coke strength). To investigate this phenomenon, the reflectograms of the 61coal samples were partitioned into 2, 3, 4, 5.....40 classes and the coefficients and RMS errors were calculated for each case. The root mean square (RMS) error for the different numbers of cells in the reflectograms are shown as File:61remRo in the appendix and as text Figure 9.

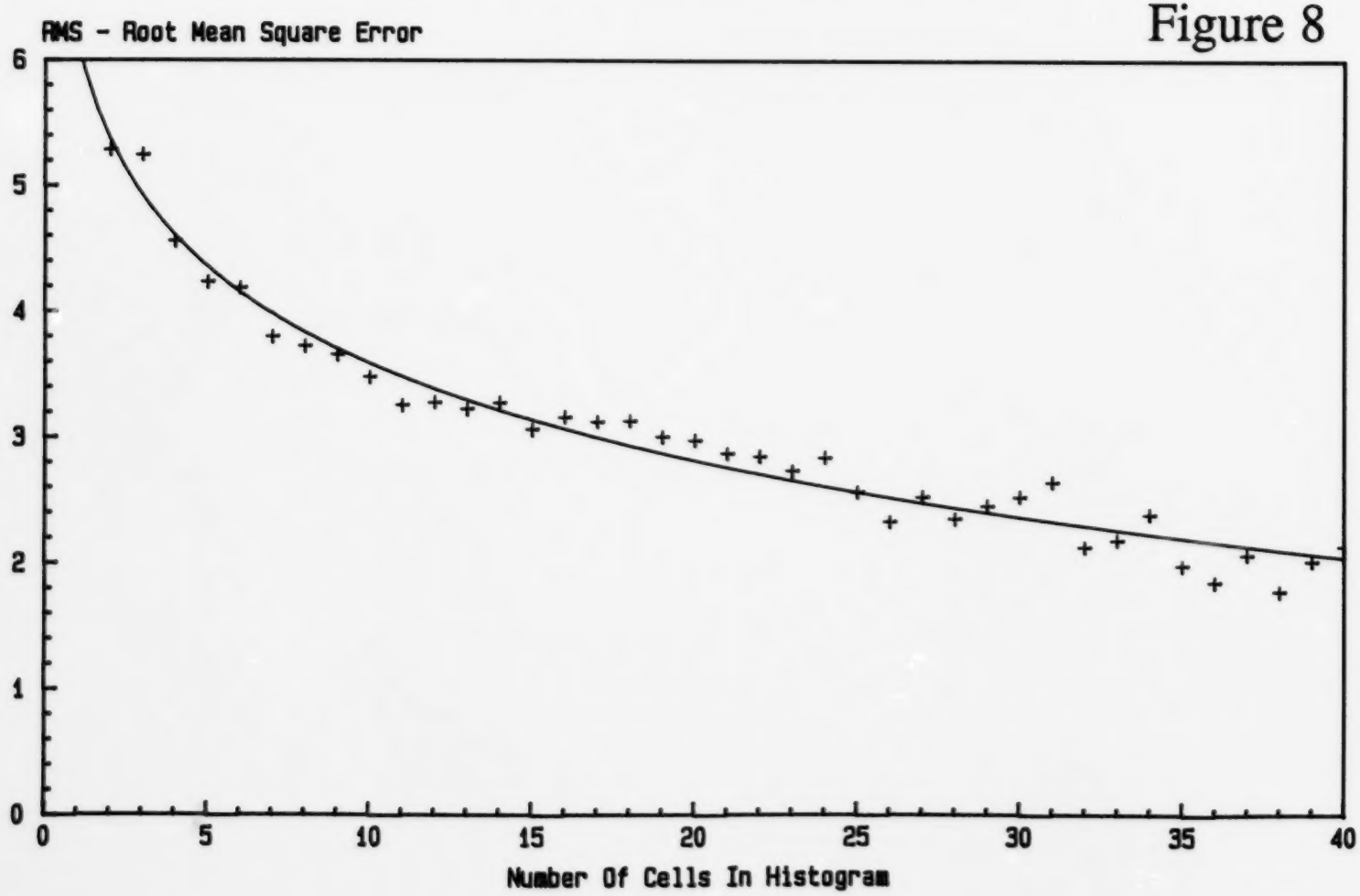
This diagram shows that for Romax predictions of ±0.03, automated reflectograms of coals from within the same population of coals should be partitioned into 18 or more classes. In this case, each class would be equal to 0.1 %Ro Random, or one V-type. For Romax predictions of ±0.02, 50 classes are required. The power curve shown in the diagram has a correlation coefficient of 0.891 and its slope, RMS = 1.1259E-001X^-0.3650E+000.

RMS Coke Strength Vs. Cell Size

Automated Reflectograms 61 Coals

Logarithmic
Curve Fit

Figure 8

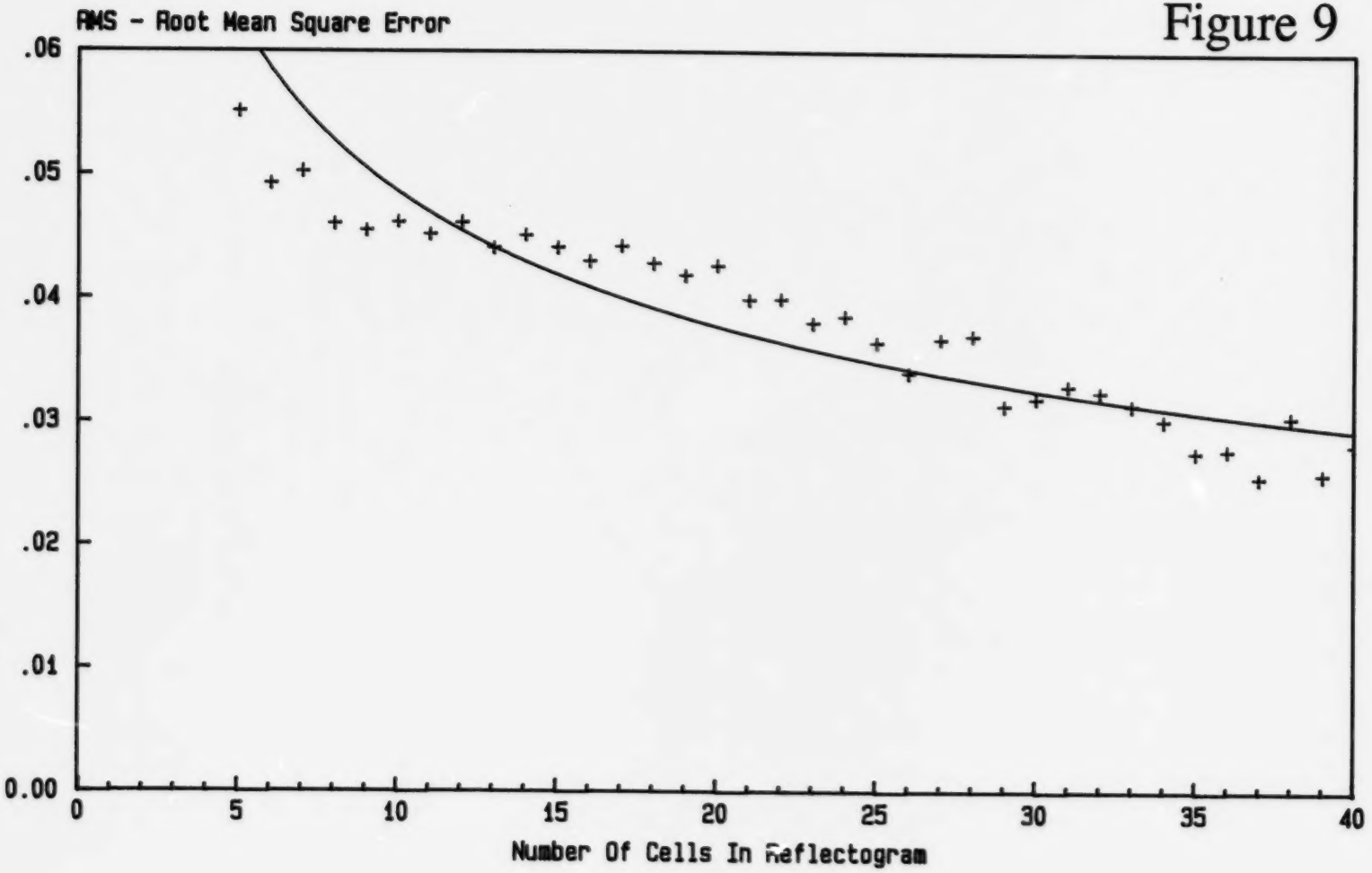


RMS Romax Vs. Cell Size

Automated Reflectograms 61 Coals

Power
Regression

Figure 9



6.0.
Discussion & Conclusions

Semi-Automated Systems.

This research has shown that from semi-automated reflectograms:

1. The random reflectance of vitrinite in the suite of western Canadian coals examined forms a normal population.

2. The semifusinite population of western Canadian coals is probably also a Gaussian distribution.

3. The population of inertinites of the coals examined was not found to be normally distributed.

The size of the inertinite population in many of the coals examined is quite small and the reflectance spread is quite large. If a normal population really is present, a very large sample would be required to confirm it. At present, based on the current sample base, a coke strength predictive technique that assumes three gaussian populations and uses nine statistical parameters to predict coke strength, will be somewhat in error. The size of this error is ±3.1 stability units.

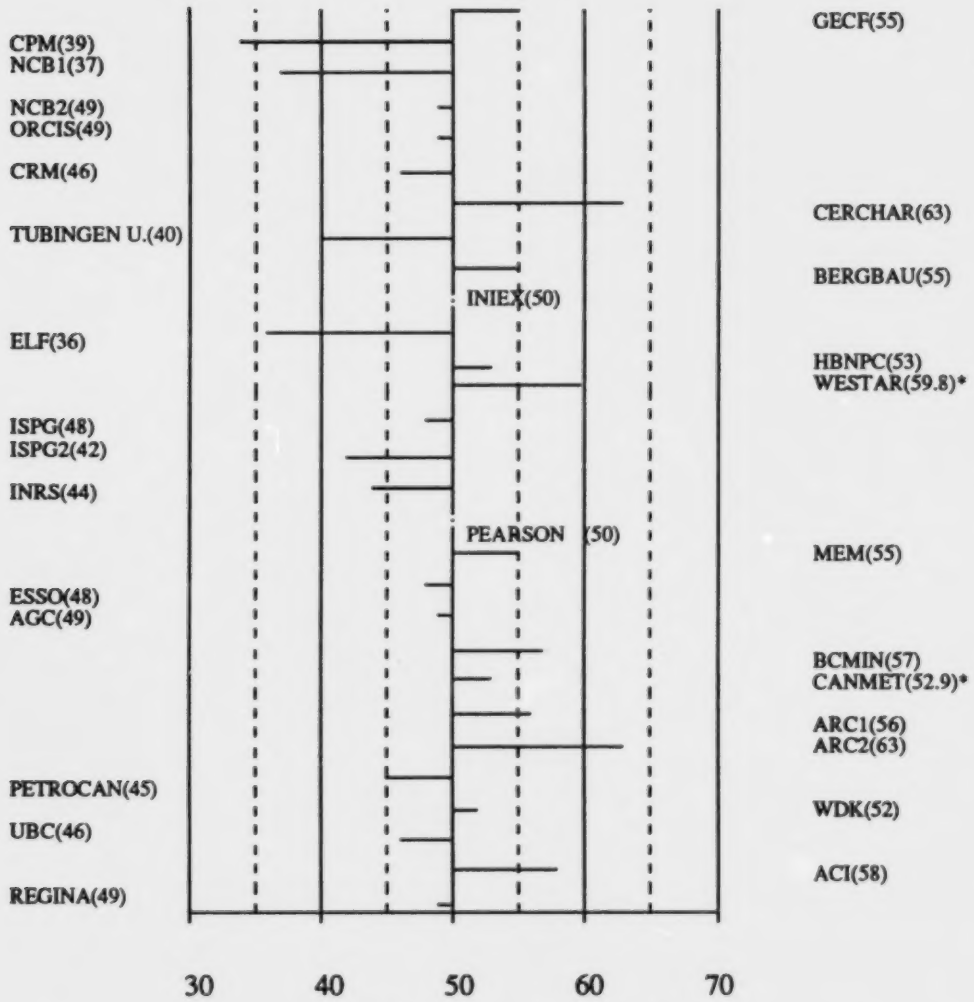
A method of shape analysis of semi-automated reflectograms, using only reflectance data with no reference to the maceral identification, was tried using multiple linear regression. This approach allows the prediction of coke strength to ±2.4 stability units using the 21-point sample set of V-types (units of 0.10 reflectance), from 0.5 to 2.5% Ro Random. The prediction improves to ±2.1 stability units by using the 25-point sample set of V-types from 0.5 to 3.0% Ro Random.

This is by far the best method of prediction of coke strength available today.

An analysis of the international round-robin results of the European-ICCP petrographers and Canadian petrographers on the Alpern sample, shows that the mean predicted stability of 29 experienced petrographers is 49.9 (which was the actual determined value), but there is a depressingly large standard deviation of ±7.6 stability units, with only 44.8% of the petrographers predicting to within ±5 stability units of the actual value. The relevant data are shown in Figure 10.

It is concluded that multiple linear regression analysis of V-types with coke strength, and the use of the derived coefficients to predict coke quality, provides the best petrographic method, to date, of coke strength prediction among distinct coal populations like the western Canadian coking coals.

Figure 10



ASTM Coke Stability Index

This diagram shows the calculated coke strength results of the European ICCP - Canadian round robin on the typical western Canadian coal identified as the Alpern sample. With the exception of two values, the coke strengths were calculated by the writer on the basis of the results contained in Dr. Alpern's circular of December 9, 1985. The Westar and CANMET values, indicated by (*), were reported separately to Dr. Cameron and the writer, and were not calculated on the same basis.

The determined coke strength was 49.9. The mean of the results is 49.9, with a standard deviation of 7.6. Only 44.8% of the respondents were within ±5 stability units (44.9-54.9).

An automated analysis (results in appendix) calculated the coke strength to be 52.6

Automated Systems

Automated reflectograms were analysed by multiple linear regression analysis, similar to the approach used in semi-automated systems. The reflectograms were partitioned into 20, 30, and 50 cells and the resulting coke strength predictions had average errors of 3.9, 4.3 & 2.9 stability units, respectively.

The root mean square (RMS) error of the full 61-suite of samples was examined for reflectograms with 2 to 40 partitions. The conclusion is reached upon examining these data that, for stability predictions of ±3 stability units, automated reflectograms should be partitioned into at least 17 cells, or into V-type cells. Should a greater accuracy be required, a spread of only ±2 stability units can be obtained by partitioning the automated reflectance data into 50 classes.

It can be concluded that predictions of coke strength can be made, with an accuracy superior to that obtained by conventional petrography, by automated systems that have no human intervention, using regression analysis of reflectance data. It should be noted however, that the applicability of this method depends upon the adequate sampling of the population of coals involved to provide reliable coefficient data.

A further set of statistical analyses were performed to extract the rank of a coal, as defined by the reflectance of vitrinite, from automated reflectograms. It is well established that the random reflectance of vitrinite has a linear relationship with the maximum reflectance but, since the polarizer was always present during these analyses, a means of obtaining Romax from the random reflectance of the automated reflectograms was desireable.

Multiple linear regression of the automated reflectance data with Romax, in partitions of 20, 30, and 50 cells was done on 57 coals of the sample suite. The derived coefficients allowed prediction of Romax with root mean square (RMS) error of 0.05, 0.03 and 0.12, respectively. Similar analyses on the full 61-sample suite show that the Romax of a sample can be predicted to within ±0.03 of the reflectance value by using 18 partitions (equivalent to V-types) and for increased accuracy, to ±0.02, using 50 partitions of the data.

Since the coke strengths of medium volatile western Canadian coking coals are relatively insensitive to changes in Romax, such errors of Romax are probably acceptable. For low- and high-volatile western Canadian coals, where coke strength is most sensitive to Romax changes, automated reflectance data may not be suitable for the additional calculation of Romax.

7.0. References

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Table 1. Kolmogorov-Smirnov data for Vitrinite

SAMPLE	N	MEAN	VAR	SKEW	LIM	K-S	%
#1827	621	1.119	0.008	-0.447	0.145	0.102	20.0
#1941	647	1.034	0.008	-0.376	0.147	0.061	20.0
#1828	695	1.060	0.006	-0.331	0.158	0.073	20.0
#1830	546	1.159	0.011	-0.474	0.136	0.079	20.0
#1864	628	0.991	0.005	0.041	0.168	0.068	20.0
#1354	480	1.154	0.011	-0.162	0.136	0.040	20.0
#1396	455	1.180	0.012	-0.211	0.133	0.052	20.0
#1349	447	1.145	0.014	-0.136	0.128	0.064	20.0
#1375	463	1.192	0.014	-0.341	0.127	0.066	20.0
#1680	618	1.010	0.004	0.018	0.169	0.049	20.0
#1471	510	1.160	0.011	-0.441	0.136	0.070	20.0
#1487	650	1.182	0.009	-0.412	0.141	0.082	20.0
#1486	515	1.143	0.012	0.072	0.133	0.036	20.0
#1565	678	0.944	0.006	-0.963	0.159	0.106	20.0
#1769	607	1.072	0.006	-0.262	0.156	0.070	20.0
#1829	430	1.164	0.015	-2.048	0.125	0.108	20.0
#1372	601	1.015	0.010	-0.327	0.140	0.076	20.0
#1373	605	1.033	0.008	0.417	0.148	0.069	20.0
#1081	618	1.114	0.009	-0.273	0.143	0.067	20.0
#2005	561	1.150	0.008	-0.339	0.145	0.071	20.0
#1073	611	1.258	0.012	-0.263	0.131	0.068	20.0
#1082	546	1.167	0.009	-0.423	0.141	0.056	20.0
#1371	586	1.490	0.015	-0.351	0.126	0.057	20.0
#2007	464	1.313	0.014	-0.140	0.128	0.046	20.0
#1699	575	1.048	0.008	-0.177	0.145	0.049	20.0
#2012	579	1.192	0.014	-0.242	0.128	0.046	20.0
#2042	638	1.137	0.010	-0.566	0.139	0.068	20.0
#2006	667	1.171	0.013	-0.316	0.129	0.064	20.0
#1506	531	1.176	0.009	-0.087	0.144	0.055	20.0
#1353	419	1.192	0.008	0.131	0.148	0.065	20.0
#1504	537	1.182	0.008	-0.123	0.145	0.039	20.0
#1604	510	1.036	0.008	-0.002	0.147	0.034	20.0
#1501	563	1.108	0.014	-0.246	0.128	0.053	20.0
#1500	508	1.032	0.011	0.003	0.136	0.048	20.0
#1505	572	1.106	0.009	-0.087	0.142	0.062	20.0
#1698	538	1.091	0.008	-0.022	0.145	0.045	20.0
#267	709	1.201	0.013	-0.323	0.129	0.047	20.0
#278	615	1.132	0.013	-0.179	0.131	0.055	20.0
#284	571	1.196	0.018	-0.193	0.119	0.048	20.0
#1374	556	1.067	0.010	-0.053	0.139	0.047	20.0
#2009	680	1.138	0.012	-0.670	0.131	0.074	20.0
#1005	578	1.274	0.013	-0.516	0.130	0.064	20.0
#1025	581	0.964	0.011	-0.516	0.136	0.066	20.0
#1026	634	1.066	0.009	-0.248	0.144	0.075	20.0
#1070	511	1.297	0.016	-0.311	0.124	0.068	20.0
#1072	595	1.330	0.013	-0.543	0.130	0.061	20.0
#2043	588	1.151	0.008	0.028	0.149	0.031	20.0
#1515	588	1.141	0.011	-0.326	0.136	0.064	20.0
#1507	560	1.179	0.008	-0.211	0.145	0.060	20.0
#2008	355	1.338	0.013	-0.367	0.131	0.060	20.0
#1080	630	1.043	0.008	-0.348	0.145	0.052	20.0
#2153	530	1.159	0.007	0.023	0.149	0.048	20.0
#2152	495	1.168	0.011	0.065	0.136	0.036	20.0
#2151	474	1.252	0.009	0.065	0.142	0.047	20.0
#416	514	1.101	0.009	-0.346	0.142	0.057	20.0
#993	749	0.836	0.004	0.057	0.170	0.056	20.0
#1068	745	0.980	0.006	-0.264	0.155	0.057	20.0

Table #1 continued

#1069	784	0.962	0.005	-0.272	0.167	0.064	20.0
#1172	789	0.831	0.008	-0.388	0.146	0.052	20.0
#417	758	1.062	0.007	-0.295	0.153	0.048	20.0
#1176	724	0.851	0.009	-0.096	0.144	0.039	20.0
#1446	779	1.510	0.019	-0.235	0.118	0.044	20.0
#1426	684	0.793	0.006	0.407	0.158	0.069	20.0
#2007	464	1.313	0.014	-0.140	0.128	0.046	20.0
#2042	645	1.137	0.010	-0.567	0.139	0.066	20.0
#1503	561	1.114	0.010	-0.524	0.139	0.053	20.0
#1699	574	1.048	0.008	-0.224	0.146	0.049	20.0
#2012	579	1.191	0.014	-0.239	0.128	0.046	20.0
#1502	602	1.125	0.012	-0.168	0.131	0.043	20.0
#1605	533	1.063	0.006	-0.000	0.155	0.033	20.0
#1582	690	1.095	0.019	-1.272	0.135	0.132	10.0
#1516	666	0.992	0.009	-0.639	0.144	0.084	20.0
#1492	649	1.001	0.005	-0.148	0.166	0.057	20.0
#1395	747	1.048	0.009	0.082	0.141	0.037	20.0
#1394	692	1.027	0.008	0.209	0.147	0.060	20.0
#1491	591	0.987	0.008	-0.914	0.146	0.081	20.0
#1451	656	0.984	0.006	-0.355	0.159	0.064	20.0
#1772	712	0.975	0.010	-2.330	0.147	0.139	15.0

Table 2. Kolmogorov-Smirnov data for Reactive Semifusinite

SAMPLE	N	MEAN	VAR	SKEW	LIM	K-S	%
#1827	100	1.286	0.011	-0.988	0.134	0.115	20.0
#1941	46	1.152	0.009	-0.636	0.163	0.160	10.0
#1828	76	1.270	0.011	-0.658	0.134	0.123	20.0
#1830	174	1.354	0.016	-0.762	0.123	0.103	20.0
#1864	70	1.144	0.016	-0.660	0.131	0.130	15.0
#1354	85	1.300	0.016	-0.848	0.157	0.144	5.0
#1396	130	1.351	0.016	-0.639	0.124	0.101	20.0
#1349	170	1.362	0.015	-0.661	0.126	0.097	20.0
#1375	166	1.432	0.017	-0.918	0.139	0.133	10.0
#1680	52	1.127	0.008	-0.278	0.145	0.123	20.0
#1471	101	1.372	0.012	-0.834	0.132	0.105	20.0
#1487	60	1.368	0.017	-0.863	0.153	0.152	5.0
#1486	143	1.348	0.016	-0.907	0.123	0.109	20.0
#1565	31	1.099	0.005	-0.457	0.167	0.114	20.0
#1769	84	1.255	0.027	-0.813	0.137	0.134	5.0
#1829	209	1.409	0.022	-0.832	0.130	0.126	10.0
#1372	87	1.242	0.011	-0.790	0.170	0.158	5.0
#1373	86	1.223	0.013	-1.015	0.130	0.119	20.0
#1081	103	1.326	0.017	-0.872	0.122	0.117	20.0
#2005	102	1.328	0.011	-1.406	0.204	0.179	1.0
#1073	85	1.474	0.012	-1.015	0.132	0.128	20.0
#1082	119	1.337	0.015	-0.693	0.142	0.142	10.0
#1371	105	1.656	0.012	-0.918	0.133	0.127	20.0
#2007	166	1.539	0.008	-1.087	0.145	0.131	20.0
#1699	132	1.247	0.012	-1.499	0.200	0.176	1.0
#2012	35	1.298	0.014	-0.682	0.147	0.142	10.0
#2042	45	1.254	0.008	-0.424	0.145	0.128	20.0
#2006	59	1.398	0.015	-1.408	0.144	0.137	10.0
#1506	98	1.389	0.008	-1.408	0.169	0.163	10.0
#1353	138	1.382	0.010	-0.693	0.157	0.154	10.0
#1504	109	1.369	0.012	-1.375	0.140	0.139	15.0
#1604	121	1.247	0.010	-1.262	0.140	0.125	20.0
#1501	106	1.346	0.020	-1.494	0.147	0.138	5.0
#1500	111	1.272	0.015	-1.024	0.132	0.130	15.0
#1505	113	1.261	0.021	-0.802	0.115	0.108	20.0
#1698	138	1.331	0.012	-1.151	0.141	0.134	15.0
#267	53	1.440	0.009	-1.117	0.162	0.153	10.0
#278	93	1.344	0.021	-1.006	0.174	0.158	1.0
#284	129	1.458	0.017	-1.475	0.185	0.172	1.0
#1374	98	1.252	0.010	-0.918	0.137	0.121	20.0
#2009	63	1.327	0.024	-1.226	0.141	0.132	5.0
#1005	141	1.479	0.015	-1.183	0.126	0.113	20.0
#1025	54	1.125	0.022	-0.751	0.173	0.171	1.0
#1026	64	1.260	0.016	-2.190	0.187	0.171	1.0
#1070	112	1.477	0.014	-1.153	0.162	0.147	5.0
#1072	76	1.501	0.014	-1.068	0.135	0.127	15.0
#2043	102	1.312	0.013	-1.037	0.197	0.165	1.0
#1515	126	1.366	0.020	-1.171	0.147	0.139	5.0
#1507	77	1.340	0.006	-1.404	0.237	0.199	1.0
#2008	186	1.561	0.008	-1.718	0.146	0.135	20.0
#1080	70	1.225	0.014	-0.789	0.128	0.111	20.0
#2153	154	1.363	0.014	-0.469	0.135	0.131	15.0
#2152	150	1.394	0.012	-1.193	0.133	0.123	20.0
#2151	166	1.433	0.009	-1.138	0.141	0.139	20.0
#416	118	1.275	0.010	-0.891	0.139	0.121	20.0
#993	62	0.896	0.014	0.349	0.134	0.129	15.0
#1068	99	1.116	0.013	-0.522	0.130	0.082	20.0

Table 2 continued

#1069	41	1.056	0.007	-0.496	0.151	0.104	20.0
#1172	45	0.918	0.052	-0.471	0.116	0.111	5.0
#417	96	1.202	0.020	-0.506	0.123	0.119	15.0
#1176	50	0.998	0.026	-0.177	0.109	0.077	20.0
#1446	50	1.757	0.014	-1.471	0.127	0.117	20.0
#1426	45	0.982	0.019	-0.807	0.213	0.191	0.1
#2007	153	1.530	0.008	-1.115	0.147	0.130	20.0
#2042	44	1.256	0.009	-0.471	0.144	0.129	20.0
#1503	86	1.288	0.021	-0.670	0.115	0.097	20.0
#1699	133	1.248	0.012	-1.507	0.200	0.176	1.0
#2012	36	1.276	0.030	-2.360	0.191	0.173	0.1
#1502	59	1.282	0.016	-2.147	0.186	0.158	1.0
#1605	128	1.264	0.015	-1.515	0.134	0.133	15.0
#1582	72	1.257	0.019	-0.531	0.118	0.093	20.0
#1516	67	1.121	0.019	-0.466	0.118	0.106	20.0
#1492	67	1.162	0.037	-1.502	0.185	0.185	0.0
#1395	35	1.106	0.015	-0.449	0.125	0.122	20.0
#1394	59	1.185	0.016	-0.546	0.141	0.139	10.0
#1491	76	1.145	0.022	-2.542	0.143	0.136	5.0
#1451	85	1.162	0.032	-0.897	0.132	0.125	5.0
#1772	273	1.456	0.200	1.466	0.099	0.088	1.0

Table 3. Kolmogorov-Smirnov data for Non-Reactive Inertinites

SAMPLE	N	MEAN	VAR	SKEW	LIM	K-S	%
#1827	279	1.722	0.067	2.232	0.156	0.142	0.1
#1941	300	1.681	0.122	2.251	0.138	0.151	0.0
#1828	226	1.756	0.118	2.262	0.139	0.156	0.0
#1830	280	1.851	0.096	2.124	0.147	0.150	0.0
#1864	279	1.693	0.135	2.941	0.135	0.173	0.0
#1354	433	1.834	0.128	3.539	0.136	0.144	0.0
#1396	412	1.847	0.073	1.740	0.128	0.113	1.0
#1349	383	1.826	0.074	1.775	0.153	0.138	0.1
#1375	371	1.930	0.109	2.578	0.142	0.159	0.0
#1680	312	1.743	0.353	5.330	0.106	0.216	0.0
#1471	389	1.889	0.148	4.628	0.131	0.176	0.0
#1487	290	1.902	0.100	1.931	0.141	0.140	0.1
#1486	342	1.789	0.072	2.988	0.157	0.158	0.0
#1565	259	1.639	0.130	1.883	0.133	0.125	0.1
#1769	298	1.796	0.110	1.745	0.142	0.149	0.0
#1829	361	1.904	0.090	2.942	0.149	0.156	0.0
#1372	306	1.739	0.098	1.851	0.142	0.131	0.1
#1373	308	1.761	0.111	1.511	0.138	0.126	0.1
#1081	279	1.856	0.120	1.774	0.139	0.152	0.0
#2005	337	1.831	0.120	1.622	0.139	0.145	0.0
#1073	304	1.946	0.088	1.673	0.146	0.137	0.1
#1082	335	1.821	0.080	1.392	0.150	0.128	0.1
#1371	309	2.121	0.100	2.267	0.145	0.162	0.0
#2007	370	1.914	0.053	1.509	0.166	0.146	0.1
#1699	278	1.696	0.115	2.563	0.140	0.175	0.0
#2012	386	1.892	0.158	4.694	0.130	0.136	0.0
#2042	317	1.950	0.246	1.502	0.116	0.172	0.0
#2006	274	1.947	0.141	1.854	0.133	0.139	0.0
#1506	370	1.816	0.097	1.816	0.146	0.150	0.0
#1353	443	1.836	0.095	2.111	0.147	0.162	0.0
#1504	353	1.803	0.069	1.749	0.155	0.134	0.1
#1604	362	1.713	0.110	1.861	0.142	0.156	0.0
#1501	327	1.830	0.074	1.360	0.127	0.123	1.0
#1500	374	1.796	0.094	1.379	0.120	0.116	1.0
#1505	313	1.829	0.105	1.697	0.140	0.128	0.1
#1698	297	1.790	0.115	2.189	0.140	0.173	0.0
#267	238	1.966	0.157	2.205	0.130	0.153	0.0
#278	292	1.929	0.162	2.236	0.129	0.155	0.0
#284	300	1.899	0.101	3.665	0.145	0.173	0.0
#1374	343	1.749	0.100	1.536	0.142	0.135	0.1
#2009	257	1.939	0.230	3.410	0.118	0.187	0.0
#1005	281	1.958	0.119	2.898	0.139	0.178	0.0
#1025	344	1.723	0.114	1.444	0.137	0.121	0.1
#1026	301	1.754	0.128	2.554	0.136	0.161	0.0
#1070	377	1.913	0.069	1.620	0.155	0.149	0.1
#1072	329	1.982	0.081	1.384	0.149	0.130	0.1
#2043	309	1.849	0.151	1.688	0.131	0.153	0.0
#1515	284	1.865	0.144	3.700	0.132	0.189	0.0
#1507	360	1.836	0.115	1.792	0.137	0.135	0.1
#2008	459	1.952	0.085	2.004	0.151	0.167	0.0
#1080	294	1.748	0.109	1.430	0.142	0.158	0.0
#2153	316	1.818	0.090	2.050	0.149	0.178	0.0
#2152	355	1.783	0.058	1.710	0.162	0.146	0.1
#2151	360	1.839	0.071	1.645	0.154	0.147	0.1
#416	368	1.695	0.084	2.336	0.152	0.171	0.0
#993	136	1.538	0.169	2.214	0.127	0.178	0.0
#1068	149	1.601	0.093	1.629	0.148	0.191	0.0
#1069	159	1.546	0.116	2.212	0.140	0.178	0.0

Table 3 continued

#1172	102	1.882	0.445	2.154	0.100	0.177	0.0
#417	133	1.706	0.111	2.926	0.141	0.187	0.0
#1176	171	2.000	0.613	2.103	0.092	0.177	0.0
#1446	171	2.733	1.090	2.207	0.080	0.241	0.0
#1426	238	1.596	0.196	2.835	0.123	0.157	0.0
#2007	383	1.905	0.053	1.504	0.166	0.145	0.1
#2042	311	1.959	0.246	1.493	0.116	0.173	0.0
#1503	349	1.882	0.124	1.351	0.134	0.133	0.1
#1699	278	1.696	0.115	2.563	0.140	0.175	0.0
#2012	385	1.893	0.157	4.706	0.130	0.138	0.0
#1502	338	1.839	0.113	1.947	0.137	0.118	0.1
#1605	337	1.762	0.132	2.318	0.135	0.166	0.0
#1582	238	1.903	0.322	4.147	0.108	0.218	0.0
#1516	267	1.751	0.165	3.009	0.128	0.148	0.0
#1492	269	1.872	0.344	3.536	0.107	0.196	0.0
#1395	175	1.779	0.135	1.294	0.110	0.105	1.0
#1394	233	1.722	0.157	3.826	0.130	0.187	0.0
#1491	297	1.729	0.115	1.433	0.137	0.122	0.1
#1451	239	1.800	0.317	3.962	0.109	0.228	0.0

Table 4. Kolmogorov-Smirnov Data for All Inertinites

SAMPLE	N	MEAN	VAR	SKEW	LIM	K-S	%
#1827	379	1.607	0.090	1.308	0.091	0.088	10.0
#1941	346	1.610	0.139	1.758	0.130	0.122	0.1
#1828	302	1.634	0.135	1.736	0.131	0.123	0.1
#1830	454	1.660	0.124	1.369	0.093	0.093	5.0
#1864	349	1.582	0.160	2.076	0.129	0.128	0.0
#1354	518	1.747	0.149	2.546	0.128	0.109	0.1
#1396	542	1.728	0.104	0.888	0.077	0.063	20.0
#1349	553	1.683	0.102	1.036	0.082	0.080	15.0
#1375	537	1.776	0.134	1.696	0.110	0.104	1.0
#1680	364	1.655	0.350	4.901	0.106	0.156	0.0
#1471	490	1.783	0.164	3.474	0.125	0.113	0.1
#1487	350	1.810	0.127	1.225	0.111	0.100	1.0
#1486	485	1.659	0.096	1.627	0.119	0.100	1.0
#1565	290	1.581	0.144	1.571	0.108	0.102	1.0
#1769	382	1.677	0.142	1.063	0.108	0.101	1.0
#1829	570	1.722	0.122	1.539	0.079	0.077	15.0
#1372	393	1.629	0.121	1.287	0.094	0.093	5.0
#1373	394	1.643	0.139	1.066	0.109	0.101	1.0
#1081	382	1.713	0.147	1.271	0.128	0.108	0.1
#2005	439	1.714	0.140	1.311	0.130	0.125	0.1
#1073	389	1.843	0.110	1.164	0.115	0.097	1.0
#1082	454	1.694	0.108	0.860	0.081	0.081	15.0
#1371	414	2.003	0.118	1.637	0.136	0.124	0.1
#2007	536	1.798	0.069	1.035	0.097	0.097	10.0
#1699	410	1.552	0.126	2.016	0.134	0.128	0.1
#2012	421	1.842	0.173	3.843	0.123	0.109	0.1
#2042	362	1.863	0.269	1.337	0.113	0.149	0.0
#2006	333	1.849	0.162	1.449	0.125	0.108	0.1
#1506	468	1.726	0.109	1.533	0.139	0.136	0.1
#1353	581	1.728	0.113	1.567	0.137	0.118	0.1
#1504	462	1.700	0.090	1.097	0.101	0.095	5.0
#1604	483	1.596	0.126	1.515	0.134	0.113	0.1
#1501	433	1.712	0.104	0.696	0.082	0.078	15.0
#1500	485	1.676	0.125	0.869	0.074	0.068	20.0
#1505	426	1.678	0.146	0.951	0.075	0.073	15.0
#1698	435	1.644	0.128	1.768	0.133	0.118	0.1
#267	291	1.871	0.171	1.873	0.127	0.129	0.0
#278	385	1.788	0.191	1.634	0.120	0.107	0.1
#284	429	1.767	0.117	2.451	0.114	0.111	1.0
#1374	441	1.639	0.123	1.133	0.112	0.098	1.0
#2009	320	1.819	0.249	2.732	0.116	0.130	0.0
#1005	422	1.798	0.135	2.084	0.110	0.109	1.0
#1025	398	1.642	0.144	0.902	0.108	0.093	1.0
#1026	365	1.667	0.144	1.987	0.129	0.127	0.1
#1070	489	1.813	0.090	1.005	0.121	0.104	1.0
#1072	405	1.892	0.104	0.893	0.098	0.097	5.0
#2043	411	1.716	0.171	1.436	0.127	0.131	0.0
#1515	410	1.712	0.159	2.652	0.105	0.105	1.0
#1507	437	1.748	0.131	1.454	0.132	0.112	0.1
#2008	645	1.839	0.094	1.674	0.144	0.122	0.1
#1080	364	1.647	0.133	1.049	0.132	0.119	0.1
#2153	470	1.669	0.111	1.432	0.138	0.130	0.1
#2152	505	1.668	0.076	1.074	0.106	0.103	5.0
#2151	526	1.711	0.087	1.236	0.102	0.101	5.0
#416	486	1.593	0.098	1.711	0.119	0.118	1.0
#993	198	1.337	0.210	1.551	0.121	0.121	0.0
#1068	248	1.407	0.118	1.231	0.114	0.108	1.0
#1069	200	1.445	0.133	1.734	0.135	0.140	0.0

Table 4 continued

#1172	147	1.587	0.522	1.610	0.096	0.114	0.0
#417	229	1.495	0.135	1.821	0.110	0.093	1.0
#1176	221	1.773	0.656	1.866	0.091	0.140	0.0
#1446	221	2.512	1.013	2.356	0.081	0.237	0.0
#1426	283	1.498	0.219	2.243	0.116	0.108	0.1
#2007	536	1.798	0.069	1.035	0.097	0.097	10.0
#2042	355	1.872	0.270	1.319	0.113	0.150	0.0
#1503	435	1.764	0.160	0.877	0.105	0.097	1.0
#1699	411	1.551	0.126	2.019	0.134	0.128	0.1
#2012	421	1.840	0.176	3.663	0.123	0.109	0.1
#1502	397	1.756	0.138	1.320	0.091	0.084	5.0
#1605	465	1.625	0.149	1.794	0.128	0.124	0.1
#1582	310	1.753	0.326	3.547	0.108	0.147	0.0
#1516	334	1.625	0.199	2.036	0.119	0.110	0.1
#1492	336	1.731	0.363	2.915	0.105	0.160	0.0
#1395	210	1.667	0.178	0.783	0.077	0.076	10.0
#1394	292	1.613	0.175	2.890	0.126	0.139	0.0
#1491	373	1.610	0.152	0.847	0.080	0.079	10.0
#1451	324	1.633	0.321	3.311	0.108	0.143	0.0
#1772	273	1.456	0.200	1.466	0.099	0.088	1.0

Table 5 File:Bigauss

VALUES OF I AND A(I) IN Y=A(0)+A(1).X(1)+...+A(N).X(N)

0	-.399939
1	8.28832E-04
2	.783768
3	8.59968
4	-2.0887E-04
5	9.38258E-04
6	.028604
7	-.0583038
8	-9.01893E-03

Vitrinite	Inertinite
X(1) - N	X(5) - N
X(2) - μ	X(6) - μ
X(3) - o	X(7) - o
X(4) - SK	X(8) - SK

	CS(obs)	CS(calc)	Diff.
1	1.44	1.45	-0.01
2	1.27	1.36	-0.09
3	1.41	1.36	0.05
4	1.53	1.51	0.02
5	1.32	1.28	0.04
6	1.45	1.50	-0.05
7	1.52	1.55	-0.03
8	1.53	1.54	-0.01
9	1.60	1.57	0.03
10	1.27	1.27	0.00
11	1.53	1.50	0.03
12	1.53	1.51	0.02
13	1.52	1.50	0.02
14	1.20	1.25	-0.05
15	1.45	1.39	0.06
16	1.60	1.56	0.04
17	1.38	1.37	0.01
18	1.38	1.38	0.00
19	1.50	1.45	0.05
20	1.46	1.48	-0.02
21	1.62	1.60	0.02
22	1.50	1.51	-0.01
23	1.81	1.80	0.01
24	1.66	1.67	-0.01
25	1.38	1.37	0.01
26	1.45	1.53	-0.08
27	1.40	1.47	-0.07
28	1.54	1.53	0.01
29	1.49	1.50	-0.01
30	1.52	1.52	0.00
31	1.51	1.51	0.00
32	1.37	1.38	-0.01
33	1.51	1.50	0.01
34	1.43	1.41	0.02
35	1.46	1.45	0.01
36	1.47	1.41	0.06
37	1.55	1.54	0.01
38	1.52	1.49	0.03
39	1.60	1.59	0.01
40	1.40	1.43	-0.03
41	1.51	1.48	0.03
42	1.64	1.61	0.03
43	1.31	1.33	-0.02
44	1.39	1.40	-0.01

Table 5 continued

45	1.62	1.67	-0.05
46	1.65	1.67	-0.02
47	1.45	1.47	-0.02
48	1.53	1.48	0.05
49	1.45	1.50	-0.05
50	1.67	1.69	-0.02
51	1.38	1.38	0.00
52	1.54	1.48	0.06
53	1.53	1.52	0.01
54	1.56	1.58	-0.02
55	1.42	1.45	-0.03
56	1.11	1.11	-0.00
57	1.30	1.30	0.00
58	1.20	1.25	-0.05

Table 6 File:Trigauss

VALUES OF I AND A(I) IN Y=A(0)+A(1).X(1)+...+A(N).X(N)

0	-.0573402			
1	1.52446E-04	Vitrinite	Reactive S-F	Inertinite
2	.1136	X(1) = N	X(5) = N	X(9) = N
3	9.27437E-04	X(2) = μ	X(6) = μ	X(10) = μ
4	.0076924	X(3) = o	X(7) = o	X(11) = o
5	3.78889E-04	X(4) = SK	X(8) = SK	X(12) = SK
6	.759299			
7	3.69882			
8	.0205177			
9	6.68576E-05			
10	.126114			
11	-.123618			
12	2.63823E-03			

	CS(obs)	CS(calc)	Diff.
1	1.44	1.43	0.01
2	1.27	1.29	-0.02
3	1.41	1.42	-0.01
4	1.53	1.54	-0.01
5	1.32	1.31	0.01
6	1.45	1.46	-0.01
7	1.52	1.52	0.00
8	1.53	1.53	-0.00
9	1.60	1.60	-0.00
10	1.27	1.26	0.01
11	1.53	1.52	0.01
12	1.53	1.53	-0.00
13	1.52	1.52	0.00
14	1.20	1.21	-0.01
15	1.45	1.46	-0.01
16	1.60	1.60	0.00
17	1.38	1.38	-0.00
18	1.38	1.38	0.00
19	1.50	1.49	0.01
20	1.46	1.46	0.00
21	1.62	1.61	0.01
22	1.50	1.50	-0.00
23	1.81	1.80	0.01
24	1.66	1.67	-0.01
25	1.38	1.38	-0.00
26	1.45	1.46	-0.01
27	1.40	1.40	0.00
28	1.54	1.54	0.00
29	1.49	1.49	-0.00
30	1.52	1.52	-0.00
31	1.51	1.50	0.01
32	1.37	1.37	-0.00
33	1.51	1.51	0.00
34	1.43	1.42	0.01
35	1.46	1.46	-0.00
36	1.47	1.47	0.00
37	1.55	1.56	-0.01
38	1.52	1.53	-0.01
39	1.60	1.61	-0.01
40	1.40	1.39	0.01
41	1.51	1.51	0.00
42	1.64	1.64	0.00
43	1.31	1.31	0.00
44	1.39	1.39	0.00

Table 6 continued

45	1.62	1.62	0.00
46	1.65	1.64	0.01
47	1.45	1.46	-0.01
48	1.53	1.54	-0.01
49	1.45	1.45	0.00
50	1.67	1.67	0.00
51	1.38	1.38	0.00
52	1.54	1.54	0.00
53	1.53	1.53	-0.00
54	1.56	1.57	-0.01
55	1.42	1.41	0.01
56	1.11	1.10	0.01
57	1.30	1.29	0.01
58	1.20	1.20	0.00

Table 7 File:Rctums

VALUES OF I AND A(I) IN Y=A(0)+A(1).X(1)+...+A(N).X(N)

0	-297.056		
1	.369031	Vitrinite	Inertinite
2	-25.6152	X(1) = N	X(9) = N
3	94.0464	X(2) = μ	X(10) = μ
4	-.764245	X(3) = σ	X(11) = σ
5	.328256	X(4) = SK	X(12) = SK
6	17.7718		
7	-22.137		
8	.635571		

CS(obs)	CS(calc)	Diff.
57.60	56.38	1.22
54.80	56.48	-1.68
61.10	59.35	1.75
58.50	52.79	5.71
54.20	50.17	4.03
41.70	51.04	-9.34
46.00	48.76	-2.76
49.90	49.83	0.07
52.90	50.82	2.08
54.90	49.80	5.10
50.40	53.89	-3.49
58.00	58.76	-0.76
52.20	52.36	-0.16
54.00	51.35	2.65
55.70	53.00	2.70
50.70	50.78	-0.08
55.40	55.98	-0.58
55.30	56.30	-1.00
59.20	56.92	2.28
52.00	53.85	-1.85
59.30	56.31	2.99
53.50	53.03	0.47
43.20	52.60	-9.40
53.00	48.99	4.01
57.10	49.85	7.25
50.90	57.11	-6.21
54.90	57.48	2.58
60.70	60.08	0.62
50.60	52.51	-1.91
42.70	47.59	-4.89
53.60	52.28	1.32
50.90	50.45	0.45
54.00	54.50	-0.50
47.70	51.79	-4.09
55.40	53.64	1.76
55.90	44.65	11.25
63.00	61.49	1.51
60.00	57.19	2.81
59.50	56.09	3.41
52.60	53.63	-1.03
61.10	60.00	1.10
60.20	54.03	6.17
49.50	51.28	-1.78
55.40	58.12	-2.72
52.90	51.39	1.51
55.20	54.89	0.31

Table 7 continued

54.30	53.67	0.63
58.10	55.13	2.97
51.80	52.89	-1.09
37.60	44.52	-6.92
56.60	56.25	0.35
55.70	51.93	3.77
51.80	51.04	0.76
52.50	48.53	3.97
48.80	52.32	-3.52
34.10	43.41	-9.31
54.70	58.16	-3.46
51.90	57.79	-5.89

SUMSQ= 916.168
RMS ERROR =3.9744

Table 8 File:Rctan

VALUES OF I AND A(I) IN Y=A(0)+A(1).X(1)+...+A(N).X(N)

0	-252.499			
1	.321624	Vitrinite	Reactive S-F	Inertinite
2	-75.3085	X(1) = N	X(5) = N	X(9) = N
3	-279.528	X(2) = μ	X(6) = μ	X(10) = μ
4	-1.08547	X(3) = o	X(7) = o	X(11) = o
5	.278655	X(4) = SK	X(8) = SK	X(12) = SK
6	84.2628			
7	136.525			
8	.273953			
9	.270769			
10	-11.011			
11	26.1984			
12	-.313305			

CS(obs)	CS(calc)	Diff.
57.60	55.34	2.26
54.80	51.11	3.69
61.10	62.58	-1.48
58.50	54.01	4.49
54.20	50.04	4.16
41.70	45.86	-4.16
46.00	45.49	0.51
49.90	49.08	0.82
52.90	52.39	0.51
54.90	52.75	2.15
50.40	53.37	-2.97
58.00	57.79	0.21
52.20	52.20	0.00
54.00	50.03	3.97
55.70	55.37	0.33
50.70	53.23	-2.53
55.40	57.35	-1.95
55.30	55.84	-0.54
59.20	59.66	-0.46
52.00	53.64	-1.64
59.30	57.30	2.00
53.50	52.13	1.37
43.20	51.48	-8.28
53.00	50.17	2.83
57.10	52.43	4.67
50.90	47.20	3.70
54.90	53.21	1.69
60.70	61.44	-0.74
50.60	53.73	-3.13
42.70	46.85	-4.15
53.60	52.09	1.51
50.90	51.66	-0.76
54.00	55.57	-1.57
47.70	52.69	-4.99
55.40	52.14	3.26
55.90	50.05	5.85
63.00	64.33	-1.33
60.00	59.50	0.50
59.50	58.44	1.06
52.60	52.53	0.07
61.10	62.77	-1.67
60.20	56.09	4.11
49.50	47.79	1.71
55.40	58.53	-3.13
52.90	48.73	4.17
55.20	53.02	2.18

Table 8 continued

54.30	53.92	0.38
58.10	58.94	-0.84
51.80	50.62	1.18
37.60	45.03	-7.43
56.60	55.84	0.76
55.70	54.27	1.43
51.80	52.53	-0.73
52.50	48.43	4.07
48.80	50.88	-2.08
34.10	41.95	-7.85
54.70	58.83	-4.13
51.90	54.93	-3.03

SUMSQ= 570.192
RMS ERROR =3.1354

Table 9. File:RGAMS21

VALUES OF I AND A(I) IN Y=A(0)+A(1).X(1)+...+A(N).X(N)

0	-17.502
1	.134768
2	.384923
3	.0575333
4	.0180865
5	.0696577
6	.0916007
7	.0912614
8	.0756575
9	.152138
10	.0257229
11	.057821
12	.0489893
13	-.10797
14	.148595
15	.187737
16	-.0612878
17	-.049478
18	.0269492
19	.148799
20	.271543
21	-.0417101

	CS(obs)	CS(calc)	Diff.
1	57.60	56.66	0.94
2	54.80	56.37	-1.57
3	61.10	59.19	1.91
4	58.50	55.71	2.79
5	54.20	50.69	3.51
6	41.70	46.30	-4.60
7	46.00	49.86	-3.86
8	49.90	51.50	-1.60
9	52.90	49.90	3.00
10	54.90	56.34	-1.44
11	50.40	49.64	0.76
12	58.00	58.67	-0.67
13	52.20	52.70	-0.50
14	54.00	52.48	1.52
15	55.70	53.74	1.96
16	50.70	48.69	2.01
17	55.40	56.13	-0.73
18	55.30	53.90	1.40
19	59.20	57.75	1.45
20	52.00	55.26	-3.26
21	59.30	57.03	2.27
22	53.50	53.81	-0.31
23	43.20	41.53	1.67
24	53.00	49.34	3.66
25	57.10	57.31	-0.21
26	50.90	55.92	-5.02
27	54.90	57.15	-2.25
28	60.70	58.04	2.66
29	50.60	50.92	-0.32
30	42.70	40.50	2.20
31	53.60	54.50	-0.90
32	50.90	53.43	-2.53
33	54.00	52.97	1.03

Table 9 continued

34	47.70	51.40	-3.70
35	55.40	54.35	1.05
36	55.90	55.43	0.47
37	63.00	61.48	1.52
38	60.00	56.72	3.28
39	59.50	55.17	4.33
40	52.60	51.59	1.01
41	61.10	58.55	2.55
42	60.20	62.36	-2.16
43	49.50	48.06	1.44
44	55.40	56.12	-0.72
45	52.90	50.91	1.99
46	55.20	54.85	0.35
47	54.30	59.20	-4.90
48	58.10	54.60	3.50
49	51.80	54.73	-2.93
50	37.60	41.44	-3.84
51	56.60	55.15	1.45
52	55.70	54.10	1.60
53	51.80	54.05	-2.25
54	52.50	54.26	-1.76
55	48.80	51.97	-3.17
56	34.10	34.49	-0.39
57	54.70	56.77	-2.07
58	51.90	53.51	-1.61

SUMSQ=330.668
RMS ERROR=2.38771

Table 10. File:RGAMS25

VALUES OF I AND A(I) IN Y=A(0)+A(1).X(1)+...+A(N).X(N)

0	-339.136
1	.481317
2	.836498
3	.345345
4	.352202
5	.386816
6	.415893
7	.417046
8	.394582
9	.472479
10	.343352
11	.352315
12	.382173
13	.214846
14	.449988
15	.546591
16	.21798
17	.271275
18	.35686
19	.548536
20	.711093
21	.313018
22	.106787
23	.621753
24	1.35888
25	.191873

	CS(obs)	CS(calc)	Diff.
1	57.60	56.07	1.53
2	54.80	57.78	-2.98
3	61.10	59.87	1.23
4	58.50	56.47	2.03
5	54.20	51.45	2.75
6	41.70	44.94	-3.24
7	46.00	48.48	-2.48
8	49.90	51.71	-1.81
9	52.90	48.67	4.23
10	54.90	54.67	0.23
11	50.40	48.48	1.92
12	58.00	58.30	-0.30
13	52.20	52.76	-0.56
14	54.00	52.96	1.04
15	55.70	53.08	2.62
16	50.70	47.95	2.75
17	55.40	56.42	-1.02
18	55.30	53.70	1.60
19	59.20	57.64	1.56
20	52.00	56.15	-4.15
21	59.30	59.14	0.16
22	53.50	52.47	1.03
23	43.20	42.32	0.88
24	53.00	50.37	2.63
25	57.10	56.08	1.02
26	50.90	55.48	-4.58
27	54.90	56.95	-2.05
28	60.70	57.52	3.18

29	50.60	49.49	1.11

Table 10 continued

30	42.70	42.35	0.35
31	53.60	54.40	-0.80
32	50.90	52.47	-1.57
33	54.00	55.93	-1.93
34	47.70	50.09	-2.39
35	55.40	56.00	-0.60
36	55.90	56.17	-0.27
37	63.00	60.22	2.78
38	60.00	57.33	2.67
39	59.50	55.46	4.04
40	52.60	52.75	-0.15
41	61.10	61.05	0.05
42	60.20	61.26	-1.06
43	49.50	47.96	1.54
44	55.40	56.02	-0.62
45	52.90	51.98	0.92
46	55.20	55.22	-0.02
47	54.30	58.10	-3.71
48	58.10	56.03	2.07
49	51.80	55.53	-3.73
50	37.60	40.32	-2.72
51	56.60	54.85	1.75
52	55.70	53.44	2.26
53	51.80	53.52	-1.75
54	52.50	54.27	-1.77
55	48.80	50.71	-1.91
56	34.10	34.30	-0.20
57	54.70	56.82	-2.12
58	51.90	53.36	-1.46

SUMSQ=264.623
RMS ERROR=2.1359

FILE:Coke20

```
VALUES OF I AND A(I) IN Y=A(0)+A(1).X(1)+...+A(N).X(N)
0    -2.033438E+02
1    +9.550207E-03
2    +1.598568E-02
3    +1.037106E-02
4    +1.589548E-02
5    +1.152587E-02
6    +1.608108E-02
7    +1.298139E-02
8    +1.750482E-02
9    +4.099427E-03
10    +2.404953E-02
11    +4.392089E-03
12    +1.803311E-03
13    +1.496722E-02
14    +3.623539E-02
15    -4.401535E-02
16    +5.261427E-02
17    +2.396468E-02
18    -5.245632E-02
19    +2.756201E-02
20    +2.795764E-02
```

M5#	COKES(OBS)	COKES(CALC)	DIFF.
1	55.70	59.74	-4.04
2	61.10	62.24	-1.14
3	54.90	57.38	-2.48
4	54.90	53.25	1.65
5	44.80	49.02	-4.22
6	61.10	59.54	1.56
7	53.00	52.10	.90
8	48.80	54.30	-5.50
9	54.40	52.09	2.31
10	34.10	35.29	-1.19
11	60.70	57.23	3.47
12	50.90	54.02	-3.12
13	37.60	38.89	-1.29
14	54.80	56.52	-1.72
15	54.20	54.48	-.28
16	50.70	50.44	.26
17	58.50	61.17	-2.67
18	55.70	54.29	1.41
19	46.60	52.82	-6.22
20	57.60	57.12	.48
21	59.50	57.21	2.29
22	63.00	56.61	6.39
23	53.50	57.33	-3.83
24	52.90	56.75	-3.85
25	55.40	53.93	1.47
26	49.50	50.68	-1.18
27	59.30	57.07	2.23
28	52.90	53.18	-.28
29	59.20	58.87	.33
30	60.00	54.68	5.32
31	60.20	56.49	3.71
32	55.20	54.78	.42
33	56.60	55.60	1.00
34	43.20	38.85	4.35
35	55.40	53.74	1.66
36	55.30	56.22	-.92

FILE:Coke20 continued

37	52.60	54.94	-2.34
38	47.70	48.56	-.86
39	54.00	51.13	2.87
40	53.60	55.24	-1.64
41	55.40	53.19	2.21
42	50.90	51.86	-.96
43	52.40	50.70	1.70
44	54.70	53.71	.99
45	51.90	52.20	-.30
46	49.80	47.24	2.56
47	52.50	50.71	1.79
48	51.80	53.53	-1.73
49	49.90	48.79	1.11
50	42.70	47.34	-4.64
51	41.70	44.32	-2.62
52	46.00	46.70	-.70
53	50.40	53.43	-3.03
54	52.20	51.89	.31
55	58.00	55.38	2.62
56	58.10	54.20	3.90
57	54.00	52.53	1.47
58	57.80	55.96	1.84
59	58.50	36.45	22.05
60	57.50	51.45	6.05
61	58.00	56.84	1.16

SUMSQ=+9.400074E+02
RMS ERROR+3.925552

FILE:Coke30

VALUES OF I AND A(I) IN Y=A(0)+A(1).X(1)+...+A(N).X(N)

0	-3.077409E+02
1	+1.485927E-02
2	+1.857014E-02
3	+1.969493E-02
4	+1.806184E-02
5	+1.483610E-02
6	+2.508286E-02
7	+1.053179E-02
8	+3.116903E-02
9	+7.782765E-03
10	+3.000659E-02
11	+1.040706E-02
12	+2.117146E-02
13	+3.920256E-02
14	-1.427529E-02
15	+2.177412E-02
16	+2.568232E-02
17	+2.448311E-03
18	+1.117608E-02
19	+4.601907E-02
20	+3.862136E-02
21	-1.658875E-02
22	-2.163816E-02
23	-3.325170E-02
24	+1.477640E-01
25	+1.175208E-02
26	-4.336363E-02
27	-5.664215E-02
28	+1.641728E-01
29	-1.619963E-01
30	+1.252125E-01

M5#	COKES(OBS)	COKES(CALC)	DIFF.
1	55.70	57.94	-2.24
2	61.10	60.27	.83
3	54.90	57.96	-3.06
4	54.90	51.82	3.08
5	44.80	46.63	-1.83
6	61.10	57.30	3.80
7	53.00	52.96	.04
8	48.80	50.49	-1.69
9	54.40	52.02	2.38
10	34.10	34.99	-.89
11	60.70	58.66	2.04
12	50.90	52.74	-1.84
13	37.60	38.73	-1.13
14	54.80	55.69	-.89
15	54.20	55.91	-1.71
16	50.70	51.44	-.74
17	58.50	58.14	.36
18	55.70	54.38	1.32
19	46.60	52.70	-6.10
20	57.60	58.87	-1.27
21	59.50	60.71	-1.21
22	63.00	58.41	4.59
23	53.50	55.61	-2.11
24	52.90	54.87	-1.97
25	55.40	54.85	.55
26	49.50	51.54	-2.04
27	59.30	58.69	.61

FILE:Coke30 continued

28	52.90	54.01	-1.11
29	59.20	60.20	-1.00
30	60.00	57.86	2.14
31	60.20	57.07	3.13
32	55.20	53.48	1.72
33	56.60	56.55	.05
34	43.20	40.61	2.59
35	55.40	55.22	.18
36	55.30	57.07	-1.77
37	52.60	56.62	-4.02
38	47.70	49.36	-1.66
39	54.00	50.68	3.32
40	53.60	53.70	-.10
41	55.40	55.73	-.33
42	50.90	49.87	1.03
43	52.40	52.64	-.24
44	54.70	51.53	3.17
45	51.90	52.93	-1.03
46	49.80	45.74	4.06
47	52.50	52.56	-.06
48	51.80	55.17	-3.37
49	49.90	49.14	.76
50	42.70	45.64	-2.94
51	41.70	43.09	-1.39
52	46.00	45.36	.64
53	50.40	51.61	-1.21
54	52.20	51.97	.23
55	58.00	54.49	3.51
56	58.10	56.81	1.29
57	54.00	50.46	3.54
58	57.80	60.44	-2.64
59	58.50	29.14	29.36
60	57.50	62.63	-5.13
61	58.00	59.38	-1.38

SUMSQ=+1.177374E+03
RMS ERROR+4.393314

FILE:Coke50

```
VALUES OF I AND A(I) IN Y=A(0)+A(1).X(1)+...+A(N).X(N)
0    -9.096166E+01
1    +2.484330E-02
2    -3.406100E-02
3    +3.245954E-02
4    +2.061660E-02
5    +2.251006E-03
6    +9.525315E-03
7    -4.432846E-04
8    +9.637481E-03
9    +6.784410E-03
10    +1.803784E-02
11    -1.053532E-02
12    +1.937040E-02
13    -9.392148E-05
14    +1.390403E-02
15    +2.235149E-03
16    +8.177378E-04
17    +4.272040E-02
18    -3.191466E-03
19    +7.432352E-04
20    +1.700654E-03
21    +1.790317E-03
22    +3.311793E-02
23    -3.487242E-02
24    -4.844329E-02
25    +9.855957E-02
26    +9.380578E-04
27    +1.197962E-01
28    -2.920545E-02
29    -2.020857E-01
30    +3.319014E-02
31    -5.013150E-02
32    +1.327831E-01
33    +1.051586E-01
34    +1.076985E-01
35    -1.032815E-01
36    -2.178287E-01
37    +8.339533E-02
38    -1.771571E-01
39    +1.859929E-01
40    +1.130500E-01
41    -4.929619E-02
42    +6.233235E-02
43    -1.446219E-01
44    -1.145625E-01
45    +3.394073E-01
46    +1.213422E-01
47    +3.806378E-03
48    -1.604260E-01
49    -3.806617E-01
50    +3.058463E-01
M5#   COKES(OBS)    COKES(CALC)   DIFF.

  1   55.70   56.86  -1.16
  2   61.10   61.16   -.06
  3   54.90   55.90  -1.00
  4   54.90   52.52   2.38
  5   44.80   44.51    .29
  6   61.10   59.13   1.97
  7   53.00   53.18   -.18
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FILE:Coke50 continued

8	48.80	49.17	-.37
9	54.40	55.08	-.68
10	34.10	34.05	.05
11	60.70	60.70	.00
12	50.90	51.18	-.28
13	37.60	37.39	.21
14	54.80	55.17	-.37
15	54.20	55.42	-1.22
16	50.70	50.22	.48
17	58.50	59.35	-.85
18	55.70	55.03	.67
19	46.60	47.67	-1.07
20	57.60	58.07	-.47
21	59.50	59.37	.13
22	63.00	62.85	.15
23	53.50	53.99	-.49
24	52.90	52.14	.76
25	55.40	56.00	-.60
26	49.50	49.73	-.23
27	59.30	59.32	-.02
28	52.90	53.11	-.21
29	59.20	58.81	.39
30	60.00	60.12	-.12
31	60.20	59.33	.87
32	55.20	55.06	.14
33	56.60	54.60	2.00
34	43.20	43.19	.01
35	55.40	54.89	.51
36	55.30	56.77	-1.47
37	52.60	53.06	-.46
38	47.70	48.95	-1.25
39	54.00	53.71	.29
40	53.60	56.19	-2.59
41	55.40	55.76	-.36
42	50.90	50.05	.85
43	52.40	52.73	-.33
44	54.70	52.64	2.06
45	51.90	52.44	-.54
46	49.80	49.87	-.07
47	52.50	52.89	-.39
48	51.80	50.93	.87
49	49.90	49.45	.45
50	42.70	43.42	-.72
51	41.70	41.21	.49
52	46.00	46.68	-.68
53	50.40	50.25	.15
54	52.20	52.56	-.36
55	58.00	57.50	.50
56	58.10	56.16	1.94
57	54.00	54.04	-.04
58	57.80	41.88	15.92
59	58.50	45.09	13.41
60	57.50	52.92	4.58
61	58.00	53.68	4.32

SUMSQ=+5.192684E+02
RMS ERROR+2.917635

FILE:61coke50

```
VALUES OF I AND A(I) IN Y=A(0)+A(1).X(1)+...+A(N).X(N)
0    +1.796554E+02
1    +1.762269E-03
2    -1.269584E-02
3    -2.431621E-02
4    +8.378121E-03
5    -8.445400E-03
6    -5.882608E-03
7    -4.542548E-03
8    -1.970384E-02
9    -4.300463E-03
10    +1.425388E-02
11    -3.571745E-02
12    +3.200528E-03
13    -1.801680E-02
14    +3.676044E-02
15    -3.060147E-02
16    -2.793402E-02
17    +1.643443E-02
18    +2.899719E-02
19    -6.584625E-02
20    +1.136986E-02
21    +4.110943E-04
22    -1.865920E-02
23    -1.917171E-02
24    -7.418696E-02
25    +5.965895E-02
26    +2.933879E-02
27    +1.361945E-01
28    -9.964243E-02
29    -1.679706E-01
30    +9.821090E-03
31    +1.135359E-02
32    +6.212561E-02
33    -6.625993E-02
34    +7.832404E-02
35    -6.388877E-02
36    -1.257066E-01
37    +1.173282E-01
38    -2.293505E-01
39    +7.069709E-02
40    +9.863777E-02
41    +9.745277E-02
42    +4.444386E-02
43    -2.841264E-01
44    -8.840497E-02
45    +2.310540E-01
46    -1.179328E-01
47    +2.385285E-01
48    -3.208368E-02
49    -4.947729E-01
50    +2.800698E-01
M5#   COKES(OBS)    COKES(CALC)   DIFF.

  1   55.70   56.47    -.77
  2   61.10   60.55     .55
  3   54.90   56.51   -1.61
  4   54.90   53.20    1.70
  5   44.80   44.61     .19
  6   61.10   58.99    2.11
  7   53.00   53.47    -.47
```

FILE:61coke50 continued

8	48.80	49.08	-.28
9	54.40	54.70	-.30
10	34.10	34.27	-.17
11	60.70	60.86	-.16
12	50.90	51.36	-.46
13	37.60	36.92	.68
14	54.80	56.05	-1.25
15	54.20	55.80	-1.60
16	50.70	49.82	.88
17	58.50	60.03	-1.53
18	55.70	54.34	1.36
19	46.60	46.82	-.22
20	57.60	58.61	-1.01
21	59.50	58.86	.64
22	63.00	62.79	.21
23	53.50	54.40	-.90
24	52.90	52.83	.07
25	55.40	55.45	-.05
26	49.50	49.27	.23
27	59.30	59.33	-.03
28	52.90	53.03	-.13
29	59.20	58.00	1.20
30	60.00	60.08	-.08
31	60.20	59.37	.83
32	55.20	54.95	.25
33	56.60	54.19	2.41
34	43.20	43.75	-.55
35	55.40	54.13	1.27
36	55.30	57.42	-2.12
37	52.60	52.63	-.03
38	47.70	48.85	-1.15
39	54.00	54.87	-.87
40	53.60	56.09	-2.49
41	55.40	55.35	.05
42	50.90	51.08	-.18
43	52.40	52.66	-.26
44	54.70	52.37	2.33
45	51.90	53.21	-1.31
46	49.80	50.34	-.54
47	52.50	52.31	.19
48	51.80	51.74	.06
49	49.90	49.71	.19
50	42.70	43.59	-.89
51	41.70	40.89	.81
52	46.00	46.77	-.77
53	50.40	50.00	.40
54	52.20	52.26	-.06
55	58.00	57.22	.78
56	58.10	56.13	1.97
57	54.00	54.03	-.03
58	57.80	57.37	.43
59	58.50	57.80	.70
60	57.50	57.66	-.16
61	58.00	58.08	-.08

SUMSQ=+6.119422E+01
RMS ERROR+1.001591

File:61cokerms

#Cells	RMS Error
2	+5.285864
3	+5.243909
4	+4.551215
5	+4.227703
6	+4.181111
7	+3.793097
8	+3.718594
9	+3.649134
10	+3.472956
11	+3.249602
12	+3.275274
13	+3.217164
14	+3.272557
15	+3.054005
16	+3.158082
17	+3.120537
18	+3.128829
19	+3.000777
20	+2.975134
21	+2.867859
22	+2.849132
23	+2.732295
24	+2.843445
25	+2.564675
26	+2.328406
27	+2.530978
28	+2.350347
29	+2.458430
30	+2.526461
31	+2.644279
32	+2.121709
33	+2.178738
34	+2.383364
35	+1.973394
36	+1.842192
37	+2.065443
38	+1.774552
39	+2.019781
40	+2.137957

File:Romax20

```
VALUES OF I AND A(I) IN Y=A(0)+A(1).X(1)+...+A(N).X(N)
0    -5.181910
1    +3.134482E-04
2    +2.822065E-04
3    +3.247776E-04
4    +3.055217E-04
5    +3.260176E-04
6    +3.419003E-04
7    +3.002019E-04
8    +4.167214E-04
9    +4.384068E-04
10    +2.233357E-04
11    +3.774779E-04
12    +1.115177E-04
13    +4.384737E-04
14    +5.947454E-04
15    -1.030621E-04
16    +5.942155E-04
17    +2.375044E-04
18    -8.552345E-05
19    +1.039977E-03
20    +3.275091E-04
M5#   ROMAX(OBS)    ROMAX(CALC)   DIFF.

  1    1.32    1.29     .03
  2    1.28    1.30    -.02
  3    1.28    1.29    -.01
  4    1.12    1.13    -.01
  5    1.57    1.59    -.02
  6    1.18    1.21    -.03
  7    1.44    1.43     .01
  8    1.19    1.18     .01
  9    1.13    1.06     .07
 10     .89     .92    -.03
 11    1.34    1.33     .01
 12    1.33    1.37    -.04
 13    1.44    1.41     .03
 14    1.12    1.15    -.03
 15    1.10    1.12    -.02
 16    1.27    1.35    -.08
 17    1.27    1.31    -.04
 18    1.19    1.14     .05
 19    1.09    1.05     .04
 20    1.23    1.22     .01
 21    1.37    1.30     .07
 22    1.31    1.22     .09
 23    1.27    1.27     .00
 24    1.41    1.42    -.01
 25    1.16    1.19    -.03
 26    1.09    1.10    -.01
 27    1.40    1.36     .04
 28    1.35    1.36    -.01
 29    1.24    1.25    -.01
 30    1.29    1.30    -.01
 31    1.40    1.39     .01
 32    1.46    1.43     .03
 33    1.16    1.18    -.02
 34    1.63    1.60     .03
 35    1.11    1.16    -.05
 36    1.15    1.21    -.06
 37    1.22    1.25    -.03
```

File:Romax20 continued

38	1.19	1.20	-.01
39	1.28	1.15	.13
40	1.30	1.29	.01
41	1.24	1.23	.01
42	1.14	1.16	-.02
43	1.15	1.14	.01
44	1.09	1.09	.00
45	1.05	1.08	-.03
46	1.32	1.32	.00
47	1.34	1.37	-.03
48	1.31	1.35	-.04
49	1.32	1.29	.03
50	1.33	1.32	.01
51	1.30	1.31	-.01
52	1.30	1.33	-.03
53	1.35	1.33	.02
54	1.30	1.30	.00
55	1.35	1.29	.06
56	1.26	1.28	-.02
57	1.05	1.08	-.03
58	1.69	1.63	.06
59	1.64	1.41	.23
60	1.60	1.64	-.04
61	1.61	1.46	.15

SUMSQ=+1.603159E-01
RMS ERROR+5.126528E-02

File:Romax30

VALUES OF I AND A(I) IN Y=A(0)+A(1).X(1)+...+A(N).X(N)

0	-7.666877
1	+5.482304E-04
2	+2.491388E-04
3	+5.407535E-04
4	+3.216178E-04
5	+5.734912E-04
6	+2.953161E-04
7	+5.497558E-04
8	+4.055979E-04
9	+5.040196E-04
10	+3.825384E-04
11	+4.663575E-04
12	+6.543542E-04
13	+3.860012E-04
14	+6.143830E-04
15	+3.115477E-04
16	+6.994770E-04
17	+1.578737E-04
18	+2.595459E-04
19	+8.650910E-04
20	-1.629740E-04
21	+9.238265E-04
22	+3.209937E-04
23	+3.813892E-05
24	+1.571733E-03
25	-7.447478E-04
26	+1.287324E-03
27	-8.703979E-04
28	+6.961474E-04
29	+6.131731E-04
30	+1.836136E-03

M5#	ROMAX(OBS)	ROMAX(CALC)	DIFF.
1	1.32	1.29	.03
2	1.28	1.30	-.02
3	1.28	1.29	-.01
4	1.12	1.12	.00
5	1.57	1.56	.01
6	1.18	1.19	-.01
7	1.44	1.45	-.01
8	1.19	1.20	-.01
9	1.13	1.10	.03
10	.89	.91	-.02
11	1.34	1.33	.01
12	1.33	1.35	-.02
13	1.44	1.44	.00
14	1.12	1.16	-.04
15	1.10	1.13	-.03
16	1.27	1.31	-.04
17	1.27	1.29	-.02
18	1.19	1.13	.06
19	1.09	1.08	.01
20	1.23	1.21	.02
21	1.37	1.35	.02
22	1.31	1.25	.06
23	1.27	1.23	.04
24	1.41	1.43	-.02
25	1.16	1.17	-.01
26	1.09	1.06	.03

27	1.40	1.39	.01

File:Romax30 continued

28	1.35	1.36	-.01
29	1.24	1.24	.00
30	1.29	1.30	-.01
31	1.40	1.39	.01
32	1.46	1.44	.02
33	1.16	1.20	-.04
34	1.63	1.63	.00
35	1.11	1.11	.00
36	1.15	1.20	-.05
37	1.22	1.27	-.05
38	1.19	1.19	.00
39	1.28	1.24	.04
40	1.30	1.29	.01
41	1.24	1.21	.03
42	1.14	1.17	-.03
43	1.15	1.15	.00
44	1.09	1.07	.02
45	1.05	1.08	-.03
46	1.32	1.28	.04
47	1.34	1.34	.00
48	1.31	1.34	-.03
49	1.32	1.32	.00
50	1.33	1.30	.03
51	1.30	1.34	-.04
52	1.30	1.30	.00
53	1.35	1.35	.00
54	1.30	1.30	.00
55	1.35	1.30	.05
56	1.26	1.29	-.03
57	1.05	1.05	.00
58	1.69	1.65	.04
59	1.64	1.47	.17
60	1.60	1.63	-.03
61	1.61	1.47	.14

SUMSQ=+9.145055E-02
RMS ERROR+3.871937E-02

File:Romax50

```
VALUES OF I AND A(I) IN Y=A(0)+A(1).X(1)+...+A(N).X(N)
 0    -1.003781E+01
 1    +7.563715E-04
 2    -3.731089E-04
 3    +1.593614E-03
 4    +6.214885E-04
 5    +4.017069E-04
 6    +9.534722E-04
 7    -1.404924E-04
 8    +1.308252E-03
 9    +6.453873E-04
 10    -1.631789E-04
 11    +1.571323E-03
 12    +3.912249E-04
 13    +4.362909E-04
 14    +3.168650E-04
 15    +1.097879E-03
 16    -2.796524E-04
 17    +1.843719E-03
 18    -4.406963E-04
 19    +1.251628E-03
 20    +2.396888E-04
 21    -8.069257E-04
 22    +3.328600E-03
 23    -6.940977E-04
 24    +6.987844E-04
 25    +1.989067E-03
 26    +1.125604E-04
 27    +8.669183E-04
 28    +5.861230E-04
 29    -2.328279E-03
 30    +1.106980E-03
 31    -2.097523E-03
 32    +4.832734E-03
 33    +3.550505E-03
 34    +4.357147E-04
 35    +1.753148E-03
 36    -3.953593E-03
 37    -3.400887E-04
 38    +2.273592E-03
 39    +4.572760E-03
 40    +1.000895E-03
 41    -7.205440E-03
 42    +2.315492E-03
 43    +3.528143E-03
 44    -4.258966E-03
 45    +6.673487E-03
 46    +4.605166E-03
 47    -9.597126E-03
 48    +1.608687E-03
 49    +5.223397E-03
 50    +5.068543E-03
M5#   ROMAX(OBS)    ROMAX(CALC)   DIFF.

  1    1.32    1.32     .00
  2    1.28    1.29    -.01
  3    1.28    1.29    -.01
  4    1.12    1.13    -.01
  5    1.57    1.57     .00
```

6	1.18	1.20	-.02

File:Romax50 continued

7	1.44	1.44	.00
8	1.19	1.21	-.02
9	1.13	1.14	-.01
10	.89	.89	.00
11	1.34	1.32	.02
12	1.33	1.34	-.01
13	1.44	1.43	.01
14	1.12	1.12	.00
15	1.10	1.10	.00
16	1.27	1.27	.00
17	1.27	1.25	.02
18	1.19	1.18	.01
19	1.09	1.08	.01
20	1.23	1.23	.00
21	1.37	1.36	.01
22	1.31	1.30	.01
23	1.27	1.27	.00
24	1.41	1.41	.00
25	1.16	1.16	.00
26	1.09	1.07	.02
27	1.40	1.39	.01
28	1.35	1.36	-.01
29	1.24	1.22	.02
30	1.29	1.30	-.01
31	1.40	1.39	.01
32	1.46	1.47	-.01
33	1.16	1.15	.01
34	1.63	1.63	.00
35	1.11	1.13	-.02
36	1.15	1.18	-.03
37	1.22	1.21	.01
38	1.19	1.19	.00
39	1.28	1.27	.01
40	1.30	1.29	.01
41	1.24	1.23	.01
42	1.14	1.15	-.01
43	1.15	1.15	.00
44	1.09	1.09	.00
45	1.05	1.06	-.01
46	1.32	1.33	-.01
47	1.34	1.34	.00
48	1.31	1.30	.01
49	1.32	1.32	.00
50	1.33	1.32	.01
51	1.30	1.30	.00
52	1.30	1.31	-.01
53	1.35	1.34	.01
54	1.30	1.30	.00
55	1.35	1.35	.00
56	1.26	1.27	-.01
57	1.05	1.04	.01
58	1.69	.89	.80
59	1.64	1.70	-.06
60	1.60	1.20	.40
61	1.61	1.28	.33

SUMSQ=+9.123772E-01
RMS ERROR+1.222988E-01

File:61remRo

#Classes	RMS Error
2	+1.174779E-01
3	+6.753393E-02
4	+6.666716E-02
5	+5.507346E-02
6	+4.921905E-02
7	+5.026128E-02
8	+4.599463E-02
9	+4.546690E-02
10	+4.619201E-02
11	+4.515650E-02
12	+4.619491E-02
13	+4.409221E-02
14	+4.515491E-02
15	+4.411467E-02
16	+4.301621E-02
17	+4.429343E-02
18	+4.285839E-02
19	+4.190272E-02
20	+4.272585E-02
21	+3.991773E-02
22	+4.001766E-02
23	+3.805922E-02
24	+3.861512E-02
25	+3.645642E-02
26	+3.398905E-02
27	+3.677527E-02
28	+3.707484E-02
29	+3.135571E-02
30	+3.199107E-02
31	+3.298654E-02
32	+3.244955E-02
33	+3.140209E-02
34	+3.017207E-02
35	+2.759414E-02
36	+2.782636E-02
37	+2.554403E-02
38	+3.050584E-02
39	+2.584122E-02
40	+2.824627E-02

File :61Coke50

BOUNDARY OF Ro FOR START OF CLASS. STARTS AT 0 ENDS AT 180 (OFFSET=0.8)

File I.D. 0 4 8 11 15 19 22 26 29 33 37 40 44 48 51 55 58 62 66 69 73 77 80 84 87 91 95 98 102 105 109 113 116 120 124 127 131 134 138 142 145 149 153 156 160 163 167 171 174 178

#2153 342 371 307 468 548 509 951 949 1755 2224 1627 1824 1218 755 745 428 530 448 352 425 385 264 312 223 223 194 152 159 108 139 126 89 105 101 80 77 63 74 56 39 43 31 23 29 10 20 11 11 6 7

#2042 323 308 263 326 347 293 512 500 985 1459 1237 2013 2212 1678 1881 899 773 505 335 316 277 186 238 128 182 163 122 120 96 116 106 71 69 74 50 57 33 45 62 33 48 49 38 44 23 41 35 27 26 18

#2009 331 331 226 369 337 283 462 443 812 1123 1049 1816 2086 1544 1812 982 961 635 362 402 345 251 291 193 217 213 147 167 115 164 142 82 106 94 57 71 46 85 63 48 71 55 47 52 37 37 40 26 29 22

#2007 453 620 662 1488 2408 2366 3132 1828 1502 730 438 486 391 265 354 243 287 262 196 264 240 153 183 94 152 104 79 84 49 56 57 37 38 42 23 17 15 22 17 13 13 14 6 13 2 5 7 5 5 2

#1828 295 261 252 238 278 216 318 219 356 364 298 512 599 581 990 874 1348 1332 1028 1281 1334 981 1129 598 655 511 312 365 254 290 250 184 219 170 112 127 78 101 86 57 87 70 39 33 28 24 29 20 26 15

#1680 370 395 356 484 674 697 1178 1366 2333 2744 1693 1523 860 440 411 310 360 363 271 323 303 224 310 201 236 209 131 175 109 145 137 95 81 75 42 54 39 44 35 16 35 25 23 18 11 11 11 7 6 8

#2233 221 230 188 257 257 199 295 232 329 423 373 670 848 781 1157 993 1352 1239 837 873 756 507 703 539 709 699 492 549 401 443 421 274 283 248 149 175 101 118 121 77 91 67 40 44 29 32 22 16 34 9

#2006 531 626 505 753 979 893 1481 1347 1931 1822 1191 1165 717 408 593 402 534 461 273 379 338 222 320 184 226 187 127 168 110 114 118 80 95 83 57 78 48 58 48 29 25 32 17 12 10 14 16 6 8 3

#2012 1302 1528 1234 2028 2268 1780 2301 1650 1594 950 438 353 286 210 254 186 216 196 122 192 165 81 111 76 59 50 45 31 25 37 35 23 21 32 12 17 12 16 6 7 2 4 6 3 3 3 1 1 1 1

#2008 3164 4253 2975 3010 1623 579 384 221 272 214 179 230 221 159 217 167 195 162 163 169 150 117 143 104 99 95 61 75 47 59 50 42 39 35 30 33 22 22 8 6 9 11 3 8 2 4 3 2 1 6

#1941 273 305 219 354 381 317 594 510 885 1198 1137 1652 1778 1327 1450 997 964 642 395 433 408 286 372 221 309 303 223 264 165 175 179 111 112 123 71 68 61 74 60 37 60 54 47 39 38 40 44 27 29 19

#1864 235 257 187 312 267 236 503 418 766 949 856 1278 1387 1220 1646 1066 1057 826 460 649 553 417 464 378 429 409 279 348 205 260 247 143 163 151 94 122 87 93 71 42 48 39 35 41 22 45 38 21 21 15

File:61coke50 continued

#1829 210 204 160 187 212 166 203 175 296 322 353 579 722 662 967 788 970 1014 706 916
900 636 742 548 752 680 527 644 488 584 548 375 352 350 217 236 161 165 177 100 138 123
93 94 48 79 52 52 47 38

#1830 463 551 495 921 1217 1254 2082 1792 2137 1920 1009 960 636 394 457 304 374 365 241
258 268 216 234 159 224 151 87 133 83 101 77 45 41 43 29 40 26 24 25 19 21 15 14
14 4 6 8 3 5 3

#1769 543 649 710 1464 2107 2046 2854 1909 1893 935 407 498 379 312 420 286 340 299 207
280 250 138 188 98 104 86 62 59 51 61 47 35 40 25 21 26 15 12 13 6 6 11 4
6 2 6 7 3 1 3

#1772 280 320 288 410 448 447 789 714 1235 1294 854 1165 914 592 718 541 741 690 566
738 719 530 575 425 478 410 284 357 222 313 249 170 186 188 105 146 89 99 80 73 66 75
38 40 26 30 34 18 27 10

#1827 296 408 359 530 596 621 1099 1139 1852 2152 1421 1465 1022 561 706 462 620 646 428
536 421 291 340 206 251 218 135 169 97 119 112 84 96 89 50 72 37 48 42 23 41 17
16 13 9 12 9 8 7 7

#284 438 541 575 1061 1457 1706 2770 2130 2320 1420 630 606 430 268 396 234 333 301 215
291 282 183 184 137 157 126 74 95 77 83 62 43 37 45 19 29 17 12 14 11 10 12 7
11 5 9 9 8 4 8

#267 750 1067 1032 1900 3139 2694 3027 1772 1330 589 234 273 261 159 239 156 154 158 99
127 125 77 90 34 66 42 36 54 40 30 41 18 20 32 19 13 9 10 15 9 4 1 4 4
4 3 4 4 2 1

#1082 514 462 418 715 872 815 1503 1444 2191 2001 1113 1191 804 429 546 393 511 482 345
419 349 248 255 208 214 201 120 128 96 139 112 80 86 61 44 74 43 60 47 33 39 31
12 21 19 8 16 11 16 6

#1070 600 675 488 697 883 688 1108 893 1358 1358 969 1264 1161 737 748 534 753 631 490
564 499 356 397 263 332 251 150 182 108 124 106 66 68 78 44 53 28 39 23 24 16 18
13 13 12 25 13 4 11 4

#1026 658 672 536 800 931 840 1431 1206 1849 1955 1337 1511 1022 563 558 342 421 405 256
343 343 207 227 139 190 158 100 96 63 74 69 56 57 53 36 43 24 40 41 19 18 40 27
22 13 22 17 17 12 9

#1025 474 467 383 589 811 863 1458 1296 1892 1865 1146 1212 927 619 722 470 580 520 369
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